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ENGINEERING:

An Illustrated Weekly Journal.

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See advertisement page 18.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
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See Advertisement last week, page 88.

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Specification and Workmanship equal to Main Line Locomotives.
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Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising, London."
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Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817
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See Advertisement, page 79, Feb. 15.

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Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
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Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
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OIL FUEL APPLIANCES,
Systems
PRESSURE, AIR, STEAM
For Boilers of all types.
KERMODES LIMITED,
35, The Temple, Dale Street, Liverpool.
Naval Outfits a Speciality,
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Supplied to the British and other Governments.
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Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Od 2487
See their Illus. Advertisement, page 91, last week.

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Inventors Advice, Handbook and Consultations free.—KINGS PATENT AGENCY, LTD. (P. T. King, Director), 146a, Queen Victoria Street, London. 35 years' refs. 1209

Rosser and Russell, Ltd.,
MECHANICAL ENGINEERS,
QUEEN'S WHARF, HAMMERSMITH, W.
Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
LATHE WORK up to 10 ft. diameter.
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Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
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&c., &c. 1526

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Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL
Tubes AND Fittings AND Steel Plates.

STEWARTS AND LLOYDS, Ltd.
GLASGOW - BIRMINGHAM - LONDON.
See Advertisement, page 63. 1872

Peter Brotherhood Ltd.,
PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 53, Feb. 15.

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1948

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Lancashire Dynamo Co. Ltd., 1920, Comprising, 480 volt, D.C. Motor, coupled to 105 volt, 830 ampere compound interpole Generator, complete with Switchboard.
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For Sale:—
TWO 18 in. CENTRIFUGAL PUMPS, 20 in. Suction Pipes, 18 in. Delivery Pipes, direct coupled to Two "Restler" Patent High Speed Engines, complete and in first-class order. Capacity of both Pumps, 20 million gallons per 24 hours to 40 ft. head.
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PATENTS. DESIGNS. TRADE MARKS.

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BRITISH and FOREIGN. Moderate charges, Long and varied practical Engineering experience valuable to Inventors. Formerly many years contributor of Patents Abstracts for "The Engineer" & "The Times."—Thanet House, Temple Bar, London, W.C.2.

For Your Repairs or any
SPECIAL MACHINERY, try
THOMAS HUNT & SONS,
Albion Ironworks,
Bridge Road West, Battersea, S.W.11.
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Gearing of all Descriptions,
GEAR WHEELS up to 10 ft. diameter.
FLY ROPE and SPUR DRIVING WHEELS up to 28 ft. diameter.
BRICK and CLAYWORKING MACHINERY of all kinds.
ENGINES:—"Uniflow," "Corliss," or Drop Valve.
CLAYTON, GOODFELLOW & CO., LTD., Blackburn. 1249

Metallography with the
Super-microscope. Paper read by Dr. Rogers, November 13th, before the Sheffield Metallurgical Society. See page 20.—F. DAVIDSON & CO., 29, Great Portland St., London, W.1.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, } ROW'S PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 8732

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LAND AND MARINE
YARROW BOILERS. 1553

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See Full Page Advt., page 40, Feb. 1.

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Walter Somers, Limited,
HALESOWEN. 7116

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works, and Showrooms: BIRMINGHAM.
See advert., page 63, Feb. 1. 8195

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LIMITED.
See Advertisement page 56. 2402

Railway Switches and Crossings
T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 1312

DAVID BROWN & SONS (Hudd.) Ltd.
Lockwood Huddersfield.
HIGH CLASS
Machine Cut Gearing
FOR EVERY PURPOSE. 1440

HEAT INSULATION.
CELITH PRODUCTS CORPORATION,
Windsor House, Westminster, S.W.1. 1675
See our Illustrated Advertisement, Feb. 8.

Electric Cranes.
Traversers.
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Lifts.
S. H. HEYWOOD & Co., LTD.,
Reddish. 1361

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
1676
See half-page Advertisement, page 65, Feb. 15.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2005

Royal Show, Leicester.

JULY 1st to 5th, 1924.

EXHIBITION OF IMPLEMENTS, &c.

The Regulations and Forms of Application for Space are now ready.

Applications must be made by THURSDAY, 20th MARCH, 1924.

Live Stock entries close on MAY 1st; Produce, Forestry and Horticultural Exhibitions on MAY 20th; Poultry on MAY 31st; Dogs on JUNE 13th; Competitions for Plantations, Home Nurseries, Orchards and Fruit Plantations on MAY 1st.

T. B. TURNER, Secretary.

ROYAL AGRICULTURAL SOCIETY OF ENGLAND,
16, Bedford Square, London, W.C.1. C 968

University of London.

A Course of Six Lectures on "PRACTICAL HYDRAULIC ENGINEERING PROBLEMS IN CONNECTION WITH NAVIGATION" will be given by Mr. O. C. A. VAN LIDTH DE JEUDE, C.E., (Formerly Civil Engineer to the Nederlands Government Public Works Department, and now Technical Managing Director, Nederlands Harbour Works Co.), at the INSTITUTION OF CIVIL ENGINEERS, (Great George Street, Westminster, S.W.1), on Mondays, Wednesdays, and Fridays, FEBRUARY 25th, 27th, and 29th, and MARCH 17th, 19th, and 21st, at 5 p.m. SYLLABUS: Dredging and Dredging Plant: Brushwood constructions: River Improvements in the Nederlands: Harbour Engineering abroad: Shipping Conditions in Port: the Zuiderzee Scheme. The Lectures will be delivered in English and illustrated with lantern slides. ADMISSION FREE, WITHOUT TICKET

EDWIN DELLER, Academic Registrar. C 896

Correspondence Courses for

Inst.Civil Engrs., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.I.E.S.I., F.R.S.A., etc., Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to S/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1903

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1879

TENDERS.

LONDON & NORTH EASTERN RAILWAY.

The Directors are prepared to receive

Tenders for the Supply of

STEELWORK for the Renewal of Three Bridges at South Dock, Sunderland. The Contract comprises about 93 tons of Steel Troughs and Decking, riveted up, jointed, &c., delivered at Park Lane Shops, Gateshead, but does not include erection. Drawings may be seen on or after the 18th instant, and detailed quantities and specification, with form of tender, can be obtained, on personal application at the Office of the Chief Engineer, North-Eastern Area, York.

Sealed Tenders, marked "Tender for Renewal of Three Bridges, South Dock, Sunderland," must be received by the Joint Secretaries, London & North Eastern Railway, Marylebone Station, London, N.W. 1, by Nine a.m., Thursday, February 28th.

The Directors do not bind themselves to accept the lowest or any Tender.

JAMES McLAREN,
G. F. THURSTON,
Joint Secretaries.

Secretaries' Office,
Marylebone Station,
London N.W. 1.
13th February, 1924. C 958

MIDLAND GREAT WESTERN RAILWAY OF IRELAND COMPANY.

RECONSTRUCTION OF STATION BUILDINGS AT SLIGO.

The Directors of the above-named Company are prepared to receive

Tenders for the Reconstruction

of the STATION BUILDINGS at Sligo Station.

Copies of the Drawings may be seen at the Chief Engineer's Office, Broadstone Station, Dublin, and Bills of Quantities may be obtained on deposit of a sum of £4, which will be refunded in the case of a *bona fide* Tender being submitted.

Tenders, sealed and endorsed "Tender for Sligo Station," must be forwarded, addressed to the Chairman, Midland Great Western Railway of Ireland Company, Broadstone Terminus, Dublin, so as to reach him not later than Monday morning, 31st day of March, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

PERCY A. HAY, Secretary.

Broadstone Terminus, Dublin.
14th day of February, 1924. C 964

LONDON & NORTH EASTERN RAILWAY.

The Directors are prepared to receive

Tenders for Renewal of the

FLOORS of four OVERBRIDGES on the York and Newcastle Railway. The Contract comprises the Supply and Erection of the whole of the Steelwork (about 63 tons), certain Concrete work, making of Macadam Road Surfaces and Removal of Existing Bridge Floors.

Drawings may be viewed on or after the 18th instant, and detailed quantities and Specification with Form of Tender obtained, on personal application at the Office of the Chief Engineer, North Eastern Area, York.

Sealed Tenders marked "Tender for the Renewal of the Floors of Four Overbridges, York and Newcastle Railway," must be received by the Joint Secretaries, London & North Eastern Railway, Marylebone Station, London, N.W.1, by Nine a.m. Thursday, February 28th.

The Directors do not bind themselves to accept the lowest or any Tender.

JAMES McLAREN,
G. F. THURSTON,
Joint Secretaries.

Secretaries' Office,
Marylebone Station,
London, N.W.1.
13th February, 1924. C 957

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of :—

1. BOLTS, NUTS, RIVETS, etc.
2. SHEFFIELD TOOLS, etc.
3. CARRIAGE DOOR HANDLES, HINGES, etc.
4. STEEL CRANKED FISHPLATES.
5. LOCKS.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked :—"Tender for Bolts, Nuts and Rivets," or as the case may be, must be left with the undersigned not later than Twelve Noon, on Friday, the 7th March, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of :—

10/- for each copy of Specification, No. 1,
5/- " " " " " " 2, 3 and 4.
2/6 " " " " " " 5.

Copies of the drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.

W. B. REYNOLDS,
for Managing Director.

91, Petty France, S.W.1.
19th February, 1924. C 989

CITY OF LIVERPOOL.

WATER ENGINEER'S DEPARTMENT.

CONTRACTS FOR THE SUPPLY OF MATERIALS, &c.

The Corporation are prepared to receive

Tenders Covering Alternative

periods of Six or Twelve Months from 1st April, 1924, in respect of the Materials, &c., set out in the undermentioned Schedules, viz. :—

(1) BRASS CASTINGS & FITTINGS. (2) CARTAGE. (3) LEAD PIPE. (4) CAST IRON PIPES. (5) MISCELLANEOUS IRON PIPES & CASTINGS. (6) SLUICH VALVES. (7) UNIFORM HATS & CAPS.

Separate Tender Forms, including Specification and Schedule, for any of the above items will be forwarded upon receipt of application in writing to the Water Engineer, Alexandra Buildings, 55, Dale Street, Liverpool.

Duplicate Forms of Tender for record purposes will not be supplied.

Tenders must be sealed and enclosed in the official envelopes provided, endorsed in accordance with the instructions in the Form of Tender, and FORWARDED THROUGH THE POST, addressed to "The Town Clerk, Municipal Buildings, Liverpool," so as to be delivered not later than Ten o'clock a.m., on Tuesday, the 4th March, 1924.

WALTER MOON,
Town Clerk. C 980

STATE ELECTRICITY COMMISSION OF VICTORIA.
Melbourne,
VICTORIA,
AUSTRALIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available upon application to :—

AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.

SPECIFICATION No. 24/7.
100,000 VOLT TESTING TRANSFORMER.

CHARGE :—10/- for the first two copies of Tender Form, Conditions of Contract and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A third copy and any further copies will be supplied for the sum of 5/- each. This charge is not returnable.

PRELIMINARY DEPOSIT :—A Preliminary Deposit of £5 is to be lodged with Tender.

The Specifications may be inspected at the above-mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders close at the Commission's office, Melbourne, on the 10th March, 1924, and prices should be cabled (cable address, "Electrocom, Melbourne") to the Commission on or before that date, and Tenders on the prescribed form, properly endorsed and addressed, must be forwarded by the following mail to :—

R. LIDDELOW,
Secretary.
State Electricity Commission of Victoria,
Melbourne, Victoria, Australia. C 943

The Director-General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES :—

MACHINE, BORING and TURNING MILLS, duplex, vertical, maximum swing 30 in., to admit 25 in. under turret. Belt driven.
LATHE, heavy duty, railway wheel, with motor for driving.

Tenders due on the 13th March, 1924.
Tender forms obtainable from above. C 988

APPOINTMENTS OPEN.

The University of Oxford will

shortly proceed to APPOINT a DIRECTOR of the INSTITUTE for Research in Agricultural Engineering at a salary of £800.

Forms of application may be obtained from the SECRETARY to the Committee for Rural Economy, by whom applications will be received till March 15. C 953

Applications are Invited

for a VACANCY as JUNIOR SCIENTIFIC ASSISTANT in the Experimental Department of H.M. Signal School, R.N. Barracks, Portsmouth. The duties are concerned with the development of Receiving Apparatus for Wireless Telegraphy. Experience of W/T Reception is essential. Preference given to candidates possessing an Honours degree in Physics and research experience.

2. The salary scale is £175-15-235 plus Civil Service Bonus, which at present increases £175 to £272 8s. The Federated Universities' Superannuation Scheme is applicable.—Applications, giving full particulars of the candidate's experience, war service, etc., should be addressed to THE SECRETARY OF THE ADMIRALTY (C.E.), Admiralty, S.W.1 not later than the 7th March. C 934

ROYAL NAVY ENGINEERING COLLEGE, KEYHAM (PLYMOUTH).

The Admiralty will

shortly REQUIRE TWO DEMONSTRATORS, one for the Electrical Engineering Laboratory and one for the Physics Laboratory.

Salary in each case £250 rising by £20 annually to £350. Civil Service Bonus is not payable in addition.

The question of applying a suitable Superannuation Scheme to these appointments is under consideration, but it must be clearly understood that no guarantee can be given that selected candidates will receive any Superannuation benefit whatever.

Applicants for the above posts should furnish particulars as to age, qualifications, and experience. Applications accompanied by copies of testimonials and references should be forwarded, not later than 1st March, to the SECRETARY OF THE ADMIRALTY (C.E. Branch), Whitehall, S.W.1. C 992

Manager Wanted for

Engineering Works in the Midlands engaged on Colliery plant and constructional engineering work.

Must have had good experience in similar capacity preferably in similar works and be of proved abilities coupled with initiative and drawing office experience. Excellent scope for suitable man.

Replies, which should give fullest particulars of experiences and copies of testimonials or references, with salary required, to be addressed to C 882, Offices of ENGINEERING.

Works Manager.—Midland

Firm of Engineers wish to APPOINT ASSISTANT or UNDERSTUDY to Works Manager. Selected Applicant must be a trained engineer, having served apprenticeship with reputable firm, and possess proofs of thorough knowledge of theory and principles of general engineering. Previous executive experience is desirable. Energy, initiative, inventiveness, enthusiasm for efficiency and broad view in labour problems are essential qualites. Fullest particulars.—Address, C 982, Offices of ENGINEERING.

Clerk of Works with Re-

inforced Concrete experience REQUIRED for job abroad.—Write, stating age, experience, etc., BOX 993, SELLS' Advertising Offices, Fleet St., E.C.4. C 946

ADMINISTRATIVE COUNTY OF LONDON.

The London County Council invites

Applications for the Position

of SUPERINTENDENT of the Main Drainage Southern Outfall, Crossness, at a salary commencing at £400 a year and rising by annual increments of £25 to a maximum of £500 a year.

The foregoing salary is based on pre-war conditions and is at present subject to temporary additions on the Civil Service scale, fluctuating according to cost of living, and making the total commencing remuneration, at present, about £968 a year. The scale of temporary additions will be revised not later than 1st September, 1924. In addition the Superintendent will be provided with house, coal and light (valued for superannuation purposes at £100 a year) free.

Candidates must not be less than 40 years of age on the latest date for receiving applications. They must be trained mechanical engineers, and should have experience of the working and maintenance of large steam pumping engines and boilers, the management and control of operative staff and experience of the operation of sewage disposal works would be a qualification.

Applications must be on the official form which gives particulars of the duties and conditions of the appointment and can be obtained from the Clerk of the Council, The County Hall, Westminster Bridge, S.E.1. Applications for forms must be accompanied by a stamped addressed foolscap envelope. The completed form must be returned to the County Hall to arrive not later than Four p.m. on Monday, 17th March, 1924.

Members of the Council's staff are not precluded from becoming candidates.

Preference will be given to men who have served or attempted to serve with H.M. armed forces during the War. Canvassing disqualifies.

JAMES BIRD,
Clerk of the London County Council. C 993

Accountant for Engineering

Works employing 500 in important provincial town and to act as assistant to General Manager. Age 30-35.—Address, giving experience, reference and salary required, C 945, Offices of ENGINEERING.

The Royal Air Force

REQUIRES ELECTRICIANS, WIRELESS OPERATORS and POWER STATION TRADESMEN. Age limits: ex-service men 18 to 30; non ex-service 18 to 26; ex-N.C.Os. up to 38 years. Pay from 24s. 6d. to 6s. 6d. per week on enlistment, and all found. Allowance for wife and children to men 26 and over.—Write, stating age, or call :—INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, London, W.C.2. C 965

There is a Vacancy for

an INSPECTOR OF EXPLOSIVES at the Home Office.

QUALIFICATIONS :—Age between 30 and 40. A thorough knowledge of "danger building" work in explosives factories, or, if an officer serving or retired, the certificate of the Advanced Class, Artillery College.

Commencing salary £500, rising to £800 per annum, with bonus on Civil Service scale.

Applications, stating qualifications and experience, should be made by letter only, to the PRIVATE SECRETARY, Home Office, Whitehall, S.W. 1, before 29th February.

Home Office.
19th February, 1924. C 986

Required, in London, A

Young and Practical ENGINEER and DRAUGHTSMAN for paper-working Machinery; good prospects. Send full particulars as to age, experience and salary required.—Address, C 951, Offices of ENGINEERING.

Sales Engineer Required,

London District, with knowledge of Power Plant Instruments, for calling on Power Stations, Consulting Engineers, etc. State full particulars, salary, connection, experience.—Address, C 993, Offices of ENGINEERING.

Engineer Required with wide

experience on general works maintenance where plant has to be kept running continuously day and night. Factory has prime movers, considerable elevating plant, and general electrical and mechanical machinery.

Fullest details of past experience, age, and salary desired should be given. The works are situated South of London.—Address, C 975, Offices of ENGINEERING.

Mechanical Engineer, about

30 to 35, as Chief Assistant. Sound practical and theoretical training, steam, hydraulic electrical knowledge. All round experience in food or similar factory advantageous. Fullest particulars with dates, salary, etc.—Address, C 976, Offices of ENGINEERING.

Reinforced Concrete.—Assis-

TANT ENGINEER (age about 30) able to take charge of the preparation of detail drawings for important Reinforced Concrete work, REQUIRED by PETER LIND & CO., 2, Central Buildings, Westminster.

Applicants should apply in writing stating full particulars of experience, age and salary required. C 979

Wanted, by London Firm,

INSPECTING ENGINEER, for inspection on the Continent of Railway and General Structural Materials.—Address, giving full particulars of experience, languages, if any, and salary required, C 995, Offices of ENGINEERING.

Civil Engineer, to Super-

vise the Construction of Water Works, REQUIRED by the GOVERNMENT of TRINIDAD for two years' service. Salary, £600 per annum. Free first-class passages out and home, and, if married, for wife and children also, not exceeding four persons. Two months' leave on full pay on satisfactory termination of agreement.

Candidates, age 25 to 35 (preferably A.M.I.C.E.), must have had wide experience as Contractors' Agents or Engineers-in-Charge of the construction of Waterworks, comprising concrete dam, filter beds, service reservoirs, cast iron and steel mains with service connections, etc.—Apply at once, by letter, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, stating age, qualifications and experience, and quoting at top of application M/12601. C 994

Designer Required for

Motor Vehicle Work. Must have had good experience in the drawing office of a motor lorry manufacturer and be fully qualified as regards his theoretical abilities.—Apply, in writing, stating age, qualifications, and positions held, to COMMANDANT, Royal Army Service Corps Training College, Aldershot. C 991

Wanted, Competent Designer

for Haulage Gears and Colliery Equipment, with sales experience and knowledge of buyers.—Address, stating salary, etc., C 944, Offices of ENGINEERING.

Wanted, Immediately,

Several SENIOR and JUNIOR DRAUGHTSMEN, for Water Tube Boiler Work. None but competent men need apply. Please state age, salary required, particulars of experience, and when at liberty.—Address, C 996, Offices of ENGINEERING.

Senior Draughtsman Required

in connection with large Electrical Machines. Electrical experience not absolutely essential, but applicant must be a senior man with sound mechanical knowledge and experience in rotating machinery.—Apply, by letter only, to EMPLOYMENT DEPT., METROPOLITAN-VICKERS ELECTRICAL Co., LTD., Trafford Park, Manchester, stating age, experience and salary required. C 983

THE BRITISH EMPIRE EXHIBITION BUILDINGS.

NOT the least interesting feature of the great exhibition, which is to open at Wembley in April, will be formed by the actual buildings in which the exhibits will be housed. These buildings are of many types, and in a number of cases are of the steel or timber and plaster construction, which is generally associated with the temporary nature of the average exhibition structure. This class of building lends itself to the obtaining of very striking effects at comparatively small cost, and architecturally many of the buildings of this type at Wembley will be found of great interest and beauty. The constructional features of such buildings do not, however, involve much work, which normally would be considered to come within the sphere of engineering, and we do not propose to deal with them in any detail. There are other buildings, however, the constructional features of which are of great engineering interest, and two of these, the Palaces of Engineering and Industry, we propose to describe fully.

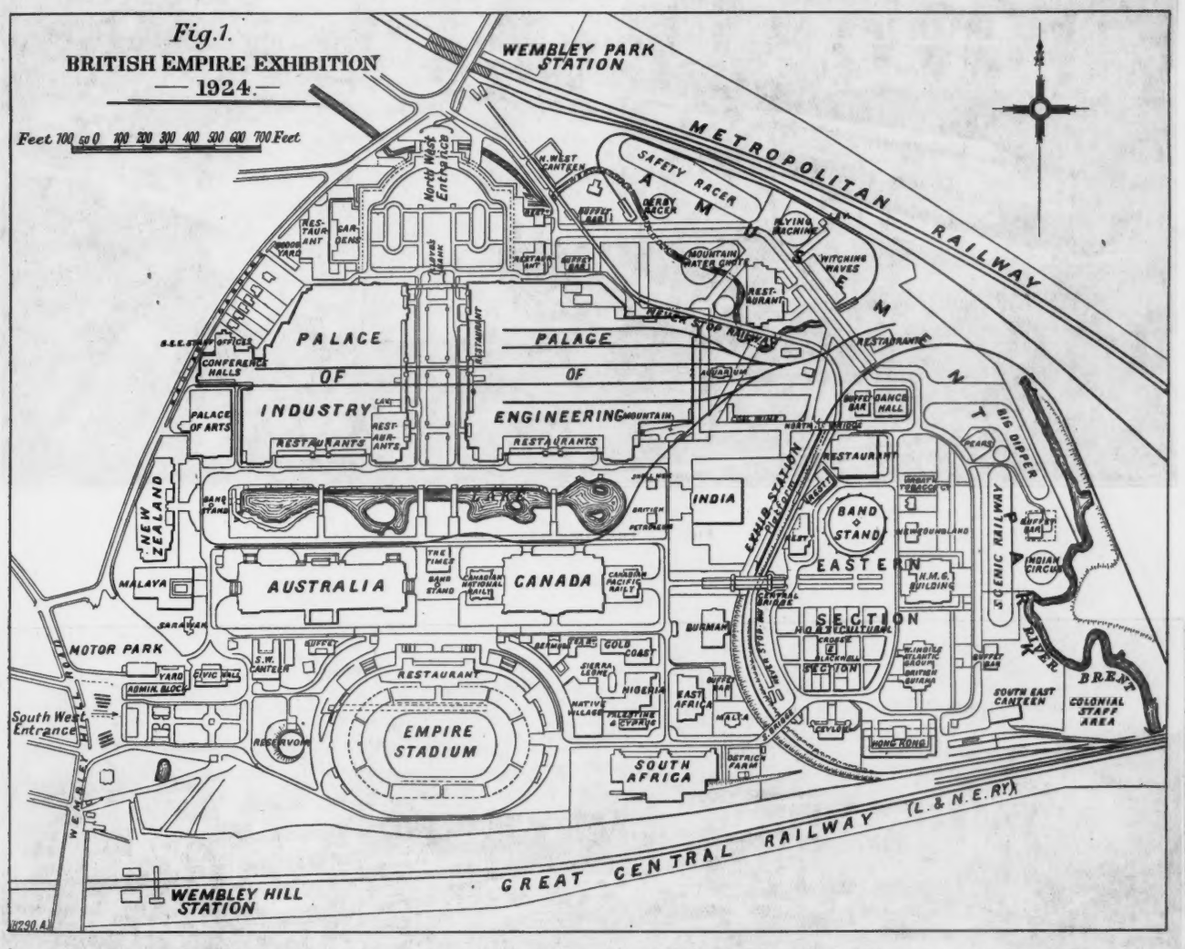
Before proceeding to the details of the buildings with which we are specially concerned, it will probably be well to refer to the main constructional features and general lay-out of the exhibition. Such a preliminary general sketch will facilitate our later description of the engineering and industry buildings. The matter will be best dealt with by a consideration of the general plan of the exhibition given in Fig. 1, annexed. As will be seen the site is a compact one and the various buildings are well together. This feature may to some extent obscure the remarkable size of the exhibition as a whole to anyone merely looking at the plan, and a sense of perspective may perhaps be introduced by pointing out that the Palace of Engineering, which is a prominent feature in Fig. 1, has a floor space of over half-a-million square feet, and covers an area six and a-half times that of Trafalgar Square. The total area of the grounds is something over 216 acres. The main architectural features are provided by the Empire Stadium, the Palaces of Engineering and Industry, and the pavilions containing the displays of Canada, Australia and India. We particularly mention these buildings both on account of their size and of the fact that they cluster about the main north and south avenue which runs through the grounds. There are, however, many other buildings of great interest and beauty, such as those erected by H.M. Government, the Union of South Africa, and many other Dominion and Colonial structures, the position of which can be seen in the plan.

Access to the exhibition will be provided on an extensive scale, both by road and rail. Omnibus and motor traffic will be considerably facilitated by a number of new routes and reconstructed main roads which have recently been completed in connection with the very extensive road programme which is being carried out in the neighbourhood of London by the Ministry of Transport in conjunction with various local authorities. The main railway services will be to the Wembley Park Station of the Metropolitan Railway, on the north side of the exhibition grounds, and Wembley Hill Station on the Great Central section of the London & North Eastern Railway on the south. This latter station will, however, be to a considerable extent relieved by a special station which has been built inside the exhibition grounds. This station will be large enough to handle 16,000 passengers hourly each way. As indicated in Fig. 1 it is served by a loop line which has been constructed from the London & North Eastern Railway. The loop where it runs through the exhibition ground lies in a cutting. The station will be served from Marylebone from where trains will run to the exhibition in ten minutes. The service from Baker Street to Wembley Park will also take about the same time. Wembley Station on the electrified Watford line of the London, Midland & Scottish Railway is also some five minutes walk from the south entrance, and Sudbury Station on the District Railway is some ten minutes away.

There are some 15 miles of roads in the exhibition grounds, and internal transport will be facilitated by a fleet of electric battery cars. Visitors entering by the northern gate will be able to travel to the amusement park and to a point near the Stadium by the "Never-Stop" railway, the position of which is indicated in Fig. 1. This is the type of railway or conveyor, due to Mr. Yorath Lewis, in which independent cars are driven by a continuously revolving screw of varying pitch. The pitch of the screw at the stations is 1 ft., and the cars pass through them at a speed of two miles an hour. The pitch increases to 8 ft. on the more open portions of the line, giving a speed of 16 miles an hour. Sufficient cars are in service on the line so that more than one are always passing through every station at two miles an hour, and passengers have never to wait for the arrival of a car unless of course, the capacity of the line is being overtaxed by the numbers who desire to use it. The line represents much the largest scale trial of the system which has yet been made, and the experience gained during the six months that the exhibition is open should be of considerable value. As will be seen from Fig. 1, the line of double track is about 1,200 yards long. It varies considerably in level, starting from Wembley Park station on a ferro-concrete viaduct, which for a considerable distance is about 22 ft. high to rail level, it traverses a cutting to pass under the London & North Eastern loop line. As will be seen it includes a number of curves, the sharpest of which is of 180 ft. radius. The screw which operates the cars is driven by a number of electric motors situated at intervals

Fig. 1.

BRITISH EMPIRE EXHIBITION — 1924.



THE BRITISH EMPIRE EXHIBITION AT WEMBLEY.

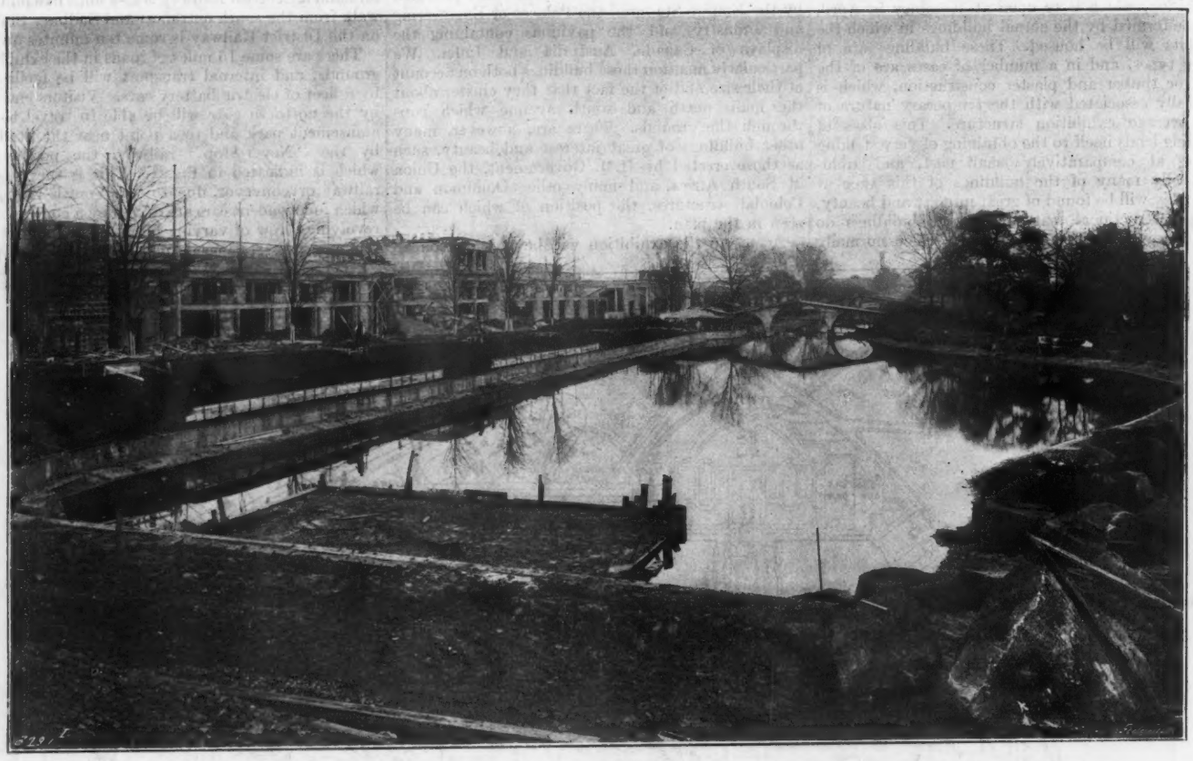


Fig. 2. The Artificial Lake.

Fig. 3. The Canadian and Australian Pavilions During Construction.

THE BRITISH EMPIRE EXHIBITION AT WEMBLEY.

FIG. 4. THE MAIN AVENUE LOOKING NORTH.

FIG. 5. FAÇADE OF THE PALACE OF ENGINEERING.

along the track. The mechanical parts of the railway are being constructed by Messrs. Sir William Arrol and Co. The civil engineering features of the line being due to Mr. E. O. Williams.

The site on which the exhibition is built has a considerable slope towards the north, and although a certain amount of levelling has taken place, particularly in connection with the Palaces of Engineering and Industry, to which we will refer more in detail later, the land has in general been left with its original contour. The Stadium is placed on the highest point, and forms a very striking background viewed from the northern end of the grounds. Although no general levelling has taken place a considerable amount of excavation of a local character has had to be undertaken by the main contractors, Messrs. Sir Robert McAlpine and Sons. This firm has been responsible for the general laying out of the grounds and for the construction of the majority of the buildings. This local excavation, which was carried out to a considerable extent by a drag-line excavator, was concerned particularly with the formation of the stadium arena, the cutting for the loop railway and

to digging out the central lake. Some important excavation was also carried out in connection with the arena surrounding the bandstand, which can be seen close to H.M. Government Buildings, at the right-hand side of Fig. 1. A large area with sloping banks has been excavated, seats capable of accommodating 10,000 people having been provided on the banks. As shown in Fig. 1, the bandstand has been erected in the centre.

The lake to which we have already referred can clearly be seen in Fig. 1, while a general view of it is given in Fig. 2, on page 226. It has a maximum depth of 1 ft. 6 in. and the bottom is lined with concrete. Almost the whole of the exhibition site lies on a fairly heavy yellow clay, and the lake has been concrete lined more with the idea of keeping the water clean than of conserving it. The natural rain-water supply is, in the main, being looked to to maintain the level of the lake, but an alternative supply is available in case of a very dry summer. The water, which can be seen in the lake in Fig. 2, was to a considerable extent supplied by the great thunderstorm of last summer. A pumping plant has been installed, so that the lake water can be circulated, screened and aerated, and so maintained in a fresh condition. While dealing with the subject of water supply we may refer to the circular reservoir which can be seen immediately to the west of the Stadium in Fig. 1. This is a steel and ferro-concrete structure, situated at one of the highest points of the ground, and with a capacity of 1,000,000 gallons. It has been constructed owing to the fact that the supply of potable water demanded by the Exhibition is somewhat greater than is continuously available in the area, which lies in the district served by the Colne Valley Water Company. The reservoir will serve as a local regulator and may be filled up during periods of low demand and drawn on when the consumption is high. A pumping station has been installed for the purpose of filling the reservoir. This stand-by water supply is connected to the fire hydrants scattered throughout the Exhibition and may be of great value in case of emergency.

As we mentioned at the beginning of this article, the exhibition buildings represent various types of construction, some being of a permanent character and others of the more or less temporary class which one usually associates with exhibitions. Of the temporary buildings the largest are those containing the displays of Canada, Australia and India. The two former of these are of a wood-framed type, with plaster facing, and special arrangements were made in connection with both their design and erection by the Dominions concerned. A view of these buildings during erection is given in Fig. 3 on page 226. The India building is a steel-framed structure, covered with fibrous plaster, and carries two minarets 110 ft. high. It was designed by Messrs. White, Allom and Co. (Sir Charles Allom), architects, Messrs. Simpson and Ayrton, F.F.R.I.B.A., the architects to the exhibition, being consulting architects, and the constructional features being due to Mr. E. O. Williams, B.Sc., the consulting civil engineer. Apart from the Canadian and Australian pavilions, Messrs. Simpson and Ayrton and Mr. Williams were responsible for practically every important building in the exhibition.

The ferro-concrete structures which are of somewhat greater engineering interest than the temporary buildings, comprise the Stadium, the Palaces of Engineering and Industry, H.M. Government Pavilion, the Conference Hall and the Palace of Art. These have all been built to the designs of Messrs. Simpson and Ayrton and Mr. E. O. Williams by Messrs. Sir Robert McAlpine and Sons. This firm also built the majority of the other pavilions which were designed by the same architects and engineer. Some of these other buildings are small only by comparison with the greater structures of the exhibition, and the New Zealand pavilion, for instance covers an area of 55,000 sq. ft., and that of South Africa 78,000 sq. ft. Practically every Empire country is represented by its own structure, and, in most cases, the architectural features of the various buildings are characteristic of the countries they represent. Thus the Indian pavilion is modelled after the Taj Mahal at Agra, and the Jama Masjid at Delhi. The Malaya building is also of Eastern type, while that of Ceylon reproduces an example of Kandyan architecture, and that of Burma is in Burmese style. The Hong Kong section reproduces a native Chinese street and that of Palestine and Cyprus is in the style of the Eastern Mediterranean. In the same way, the East Africa building is a copy of an Arab palace, and that of West Africa reproduces a typical fortified West African mud village. The West Indian and Atlantic Group utilise the Colonial Georgian style.

The ferro-concrete structures, in general, follow the classical tradition in their architectural features, and Figs. 4 and 5, on page 227, which show the façades of the Palaces of Engineering and Industry, give a good idea of the effect which has been achieved. Fig. 4 is a view taken looking north up the main avenue, and shows the Palace of Engineering on the right and the Palace of Industry on the left. The construction of these buildings we propose to describe in detail, so at the moment we need refer to them no further. Before concluding this introduction to our main subject, however, we may refer a little more fully to H.M. Government building, which is a very remarkable example of modern ferro-concrete work. This building has floor space equivalent to roughly three floors and covers an area of 44,000 sq. ft., it contains a water stage 70 ft. wide, and accommodation for 800 spectators, in addition to many side galleries, royal apartments, and other features. The decision to construct this building was only come to last August, but it is now nearly completed. It is interesting to note that the original intention was to erect a steel building, and that the decision to change over to ferro-concrete was made solely for the reason that this material would save valuable time by allowing an immediate start to be made. The reinforcement has been specially arranged to involve as few different sizes of bars as possible, so that there would be no delay in waiting for special sizes, while panels and walls have been designed to minimise the number of different wood forms required. The change which was made is amply justified by the condition of the building to-day.

(To be continued.)

COAL-GAS PLANT AT THE GREAT WESTERN RAILWAY WORKS, SWINDON.

[(*Continued from page* 169.)]

Having described the design and construction of the retorts and their settings in our previous article, we now propose to deal with the means employed for supplying the retorts with coal and the producers with coke. Referring back to the longitudinal section, cross-section and plan of the retort house, given in Figs. 5, 6 and 7, on Plate IX published with our issue of the 8th inst., it will be seen that a row of steel-plate bunkers is mounted above each bench. The bunkers are divided into compartments for coal and coke respectively, the coke compartments being situated centrally over each bed and the coal compartments filling the intermediate space, so that they each extend over a part of two adjacent beds; Fig. 5 shows the arrangement most clearly, the centres of the beds being indicated in this illustration by the positions of the chimneys. The bunkers hold sufficient coal to supply the retorts working at full capacity for 48 hours and the coke capacity is sufficient to supply the producers for 72 hours, it having been designed so that the plant can be worked over a week end at its maximum output without refilling the bunkers. A view of the bunkers is given in Fig. 51, on Plate XVI. It will be remembered that each bed comprises four retorts and one producer, and, for reasons which will be explained later, it is necessary to arrange for a supply of coke as well as of coal to all the retorts. Coke only is supplied to the producers, and the arrangements for this call for no particular comment. As shown on the right of Fig. 4, on page 166 *ante*, the coke falls through an outlet in the hopper-shaped bottom of the bunker, controlled by a plate valve which is operated by a chain, and passes down a vertical chute placed immediately over the mouth of the producer. The latter is normally closed by a cover, which is, of course, removed to admit the coke. About 7 cwt. of coke is supplied at a time, this quantity being sufficient for about four hours' working.

The arrangements for the supply of either coal or coke to the retorts can best be followed by reference to Figs. 8 and 9, on page 167 *ante*, and Fig. 18, on Plate XIV, while the details are shown in Figs. 21 to 26 on Plate XV, published with this issue. From Figs. 8 and 9 it will be seen that the upper end of each retort is fitted with a casting to which the gas-outlet pipe is connected and in which three poke holes, closed by balls, are provided. One side of this casting is formed as a hopper, to which is bolted a steel-plate container in the form of an inverted truncated pyramid. On top of the container are two hoppers one of which (that on the left of Fig. 9) is situated immediately below an opening in the bottom of one of the coal bunkers, while the other is just below a similar opening in a coke bunker. Between the two hoppers is a large plug valve, by turning which either hopper can be put into communication with the container, so that the latter can be filled with coal, or coke can be passed straight through it into the retort without disseminating dust. As the charge in the retort sinks, fresh coal gravitates from the container, which holds 8 cwt., or sufficient for two hours' working.

It should be noted from Fig. 8 that the coal is delivered into the retort between two guide plates, so that it is prevented from obstructing the gas outlet. Moreover, the effect of this central delivery is automatically to separate the nuts from the fine coal and deliver the latter towards the centre of the retort while distributing the former around the sides. Sections of the hoppers, valve and container are given in Figs. 21 and 22 on Plate XV, while Fig. 23 is a plan of the two hoppers, and Fig. 24 a plan showing the connection of the latter to the container. Fig. 25 is a horizontal section through the valve, while Fig. 26 is a vertical section on a larger scale, from which the construction can be easily followed. The valve, it will be noticed, is operated by a large handwheel through an inclined shaft and bevel gearing; the handwheel is a prominent feature of Fig. 18, on Plate XIV. In its intermediate position, the valve closes both openings to the hoppers, making a gas-tight joint, and preventing the entrance of air to the retorts, which work under a slight vacuum. It should also be noticed that the facts that the axis of the valve is vertical and that it can make a complete revolution, prevent it from becoming clogged with dust or small coal. The arrangement has been found to work quite satisfactorily in practice, the vertical valve having no tendency to shear the coal while closing. Fig. 27 is a sketch showing the arrangement of the hoppers, valves and containers for supplying three retorts, of which the two on the left belong to one bed, while the one on the right belongs to the adjacent bed.

The three poke holes in the casting forming the upper end of the retort, clearly shown in Fig. 18, enable the charge of green coal to be probed to prevent it from adhering to the sides of the retort, an operation which is carried out at intervals of about an hour. A poke hole closed by a taper plug is also provided in the side of the container, as shown in Fig. 22, and this enables the coal to be dislodged, if it should jam in the inlet to the retort. Another operation which has to be carried out in connection with the working of the retorts, and known as "scurfing," may now be referred to. It will be understood that in the course of time the internal surface of each retort becomes coated with a carbonaceous deposit, the rate of growth of this deposit depending upon the class of coal employed and the working conditions. At Swindon the deposit attains an average thickness of about 1¼ in. after 42 days' working, and when this thickness has been reached, the retort is laid off for scurfing. For this operation the supply of coal to one of the retorts of a bed is stopped and the retort is disconnected from the foul main. The coke-extracting mechanism continues to work so that the retort is gradually emptied and it is then opened at the top and bottom. This allows air to circulate through the retort, but as the retort is still heated to its normal working temperature, the deposit is burnt off after about 24 hours. To put the retort to work again, it is first filled

GAS PLANT WITH DEMPSTER-TOOGOOD RETORTS AT SWINDON.

CONSTRUCTED BY MESSRS. R. DEMPSTER AND SONS, LIMITED, ENGINEERS, ELLAND, YORKSHIRE.

(*For Description, see Page* 228.)

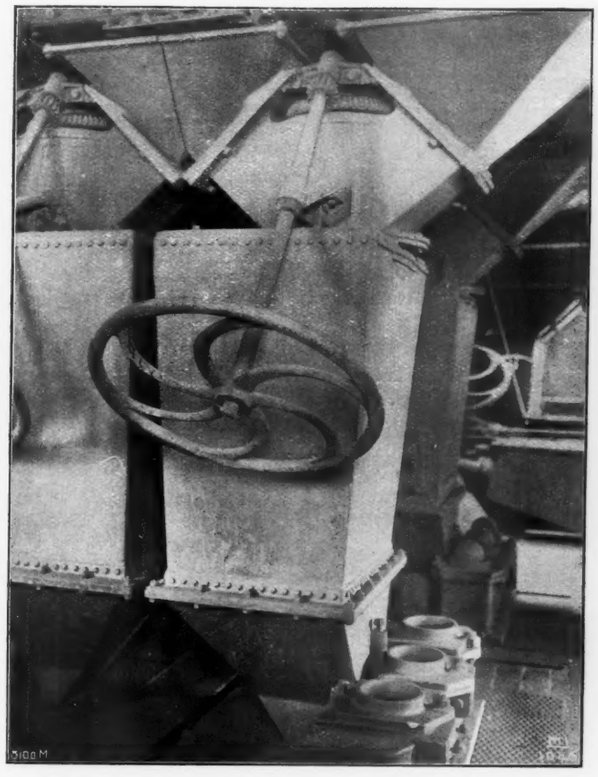


FIG. 18. FUEL CONTAINERS AND CHARGING GEAR OVER RETORTS.

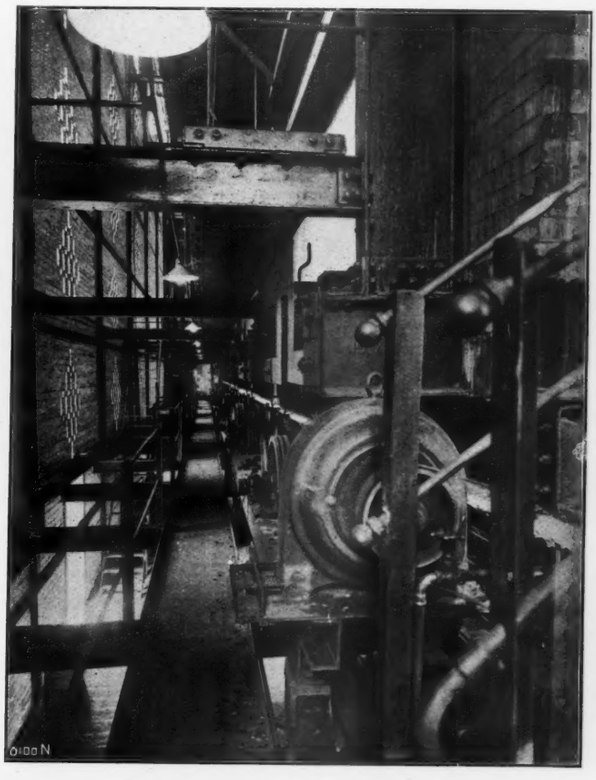


FIG. 19. MOTOR DRIVING COKE-EXTRACTOR GEAR.

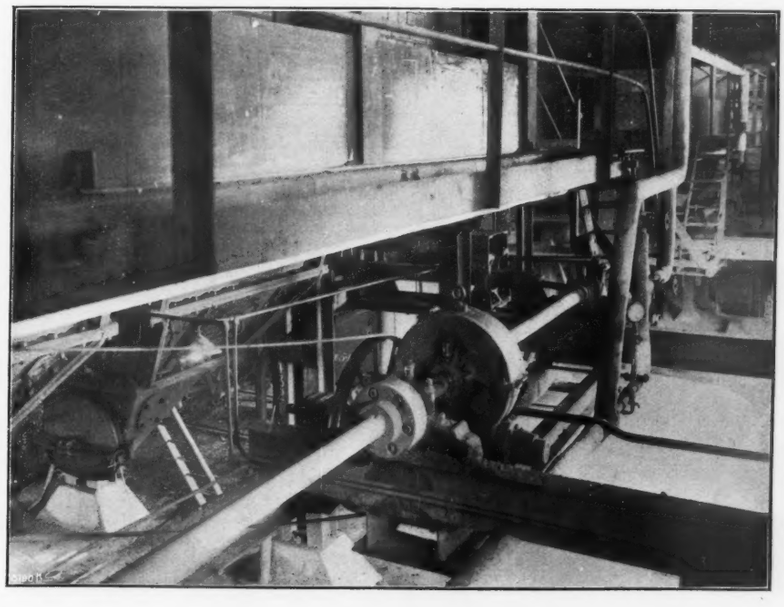


FIG. 20. COKE EXTRACTOR DRIVE AT END OF BENCH.

(*To face page* 228.)

DETAILS OF DEMPSTER-TOOGOOD CONTINUOUS VERTIC

CONSTRUCTED BY MESSRS. R. DEMPSTER AND S[illegible] LIMITE

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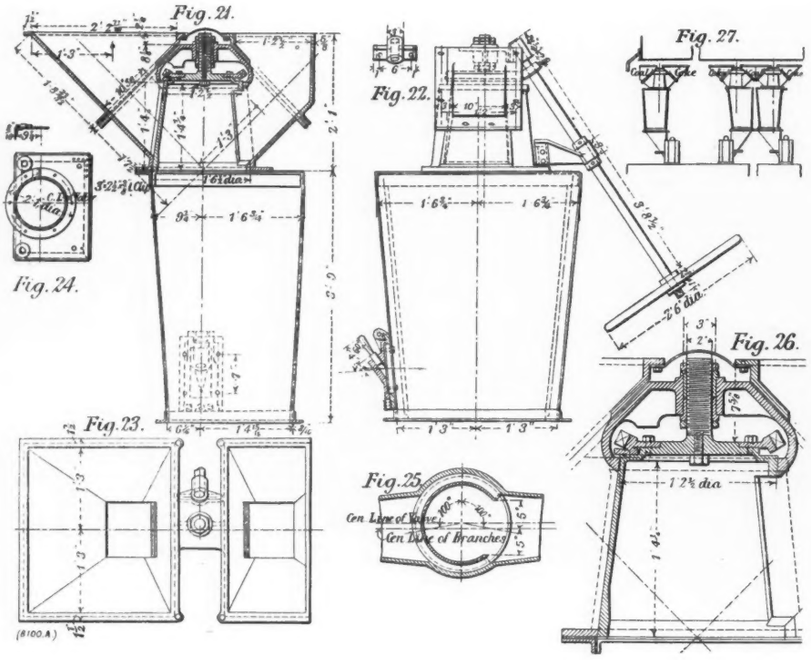


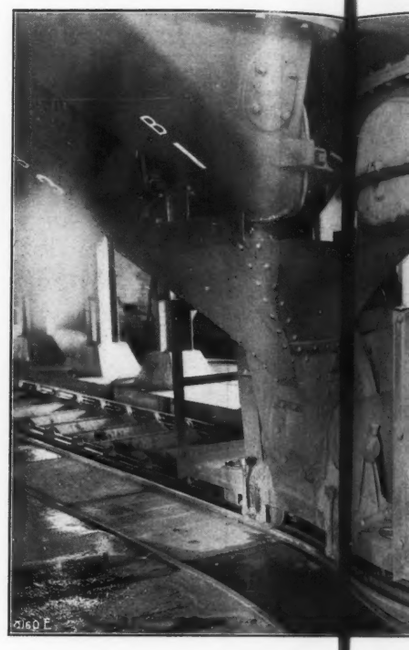
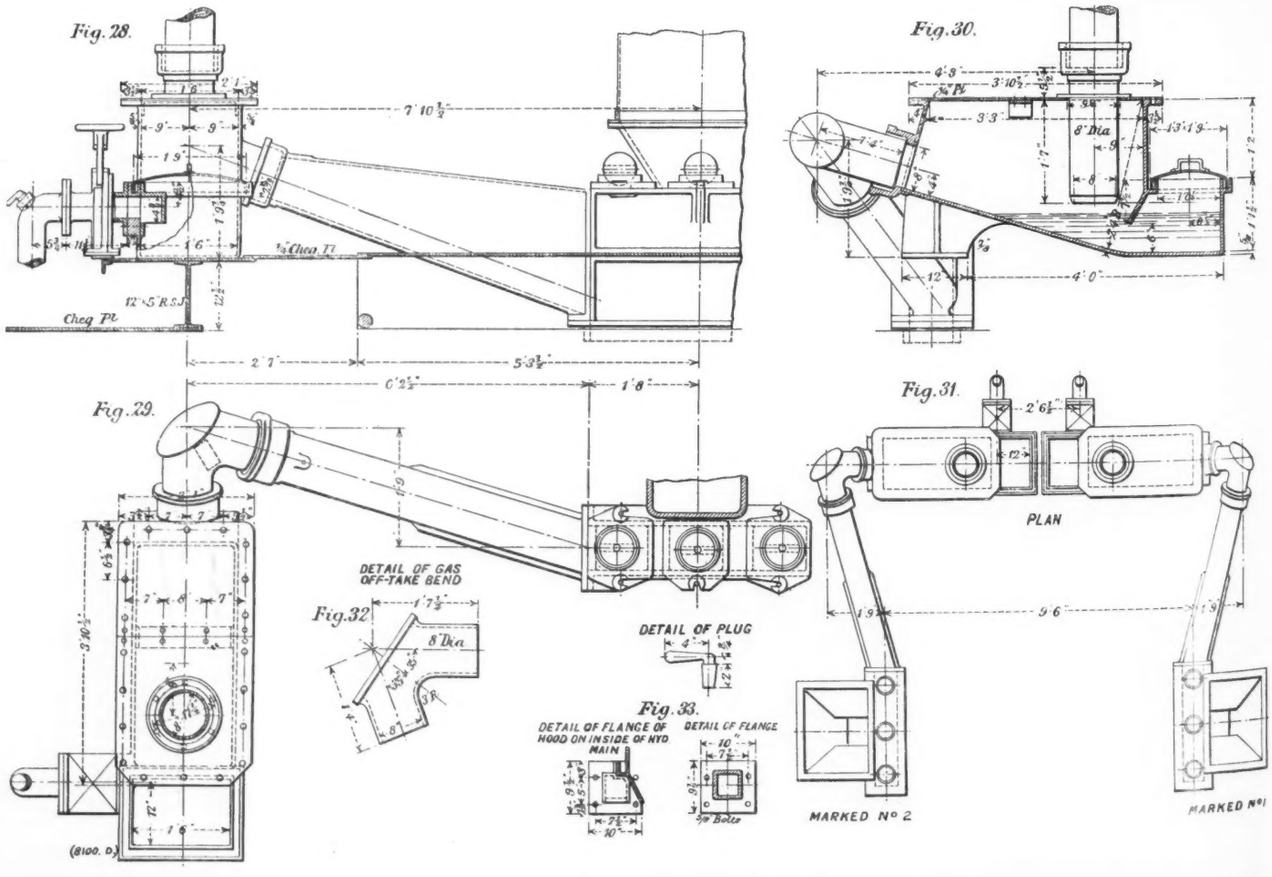


FIG. 34. COKE OUTLETS AND ROTARY [illegible]LER FOR C

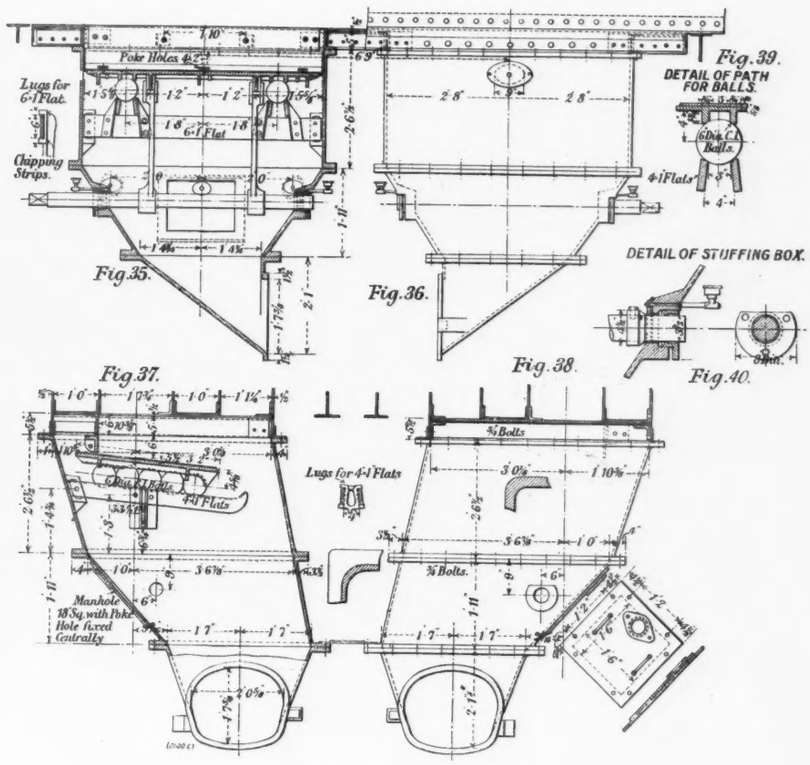


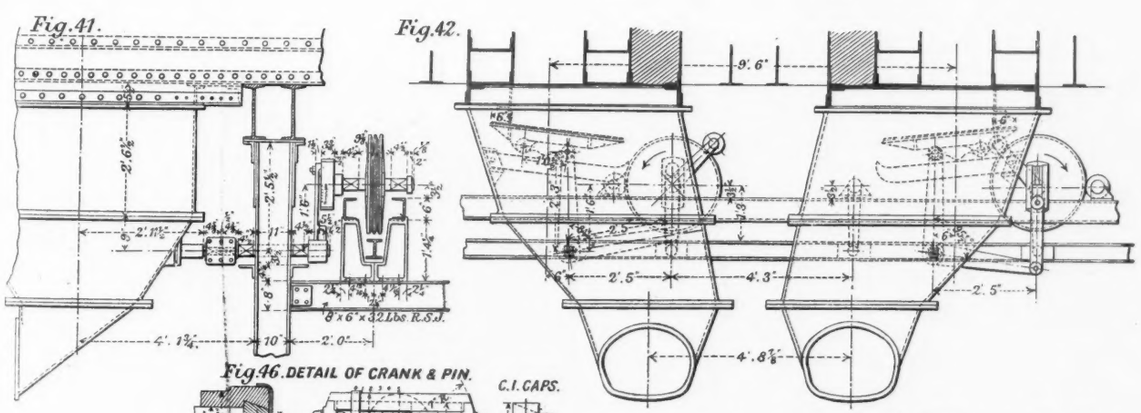
...OUS VERTICAL RETORTS AT SWINDON RAILWAY WORKS.

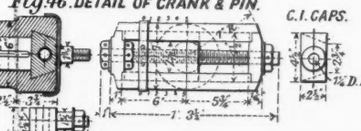
...TER AND ... LIMITED, ENGINEERS, ELLAND, YORKSHIRE.

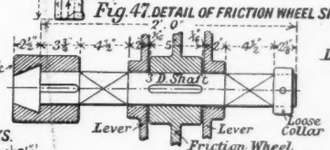
(For Description, see Page 228.)

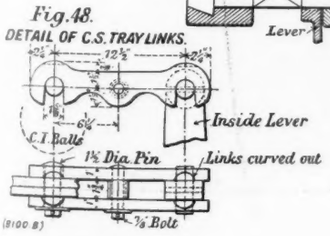
...ND ROTARY ...LER FOR GRAVITY-BUCKET CONVEYOR.

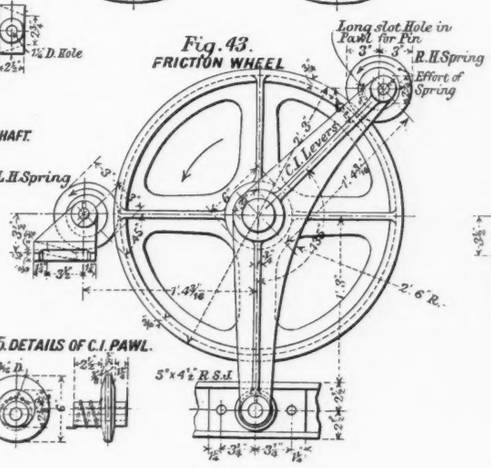


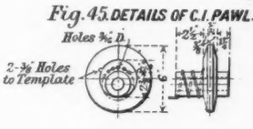


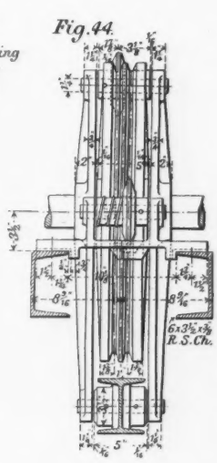












GAS PLANT WITH DEMPSTER-TOOGOOD CONTINUOUS VERTICAL RETORTS AT SWINDON.

CONSTRUCTED BY MESSRS. R. DEMPSTER AND SONS, LIMITED, ENGINEERS, ELLAND, YORKSHIRE.

(*For Description, see Page* 228.)

FIG. 49. RETORT HOUSE FLOOR AT ASH-PIT LEVEL.

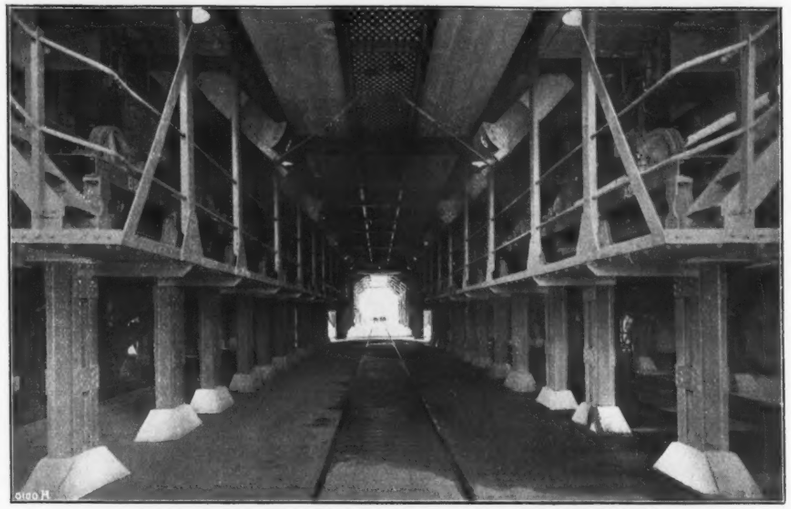


FIG. 50. GROUND FLOOR OF RETORT HOUSE.

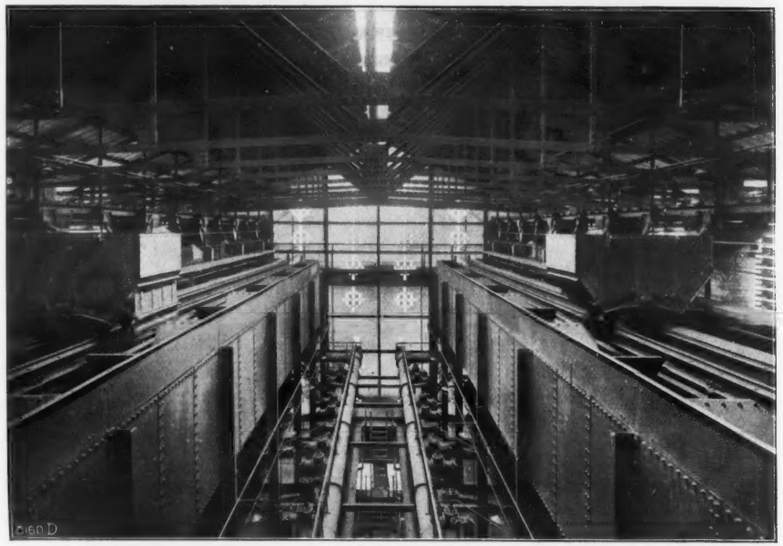


FIG. 51. COAL AND COKE BUNKERS OVER RETORTS.

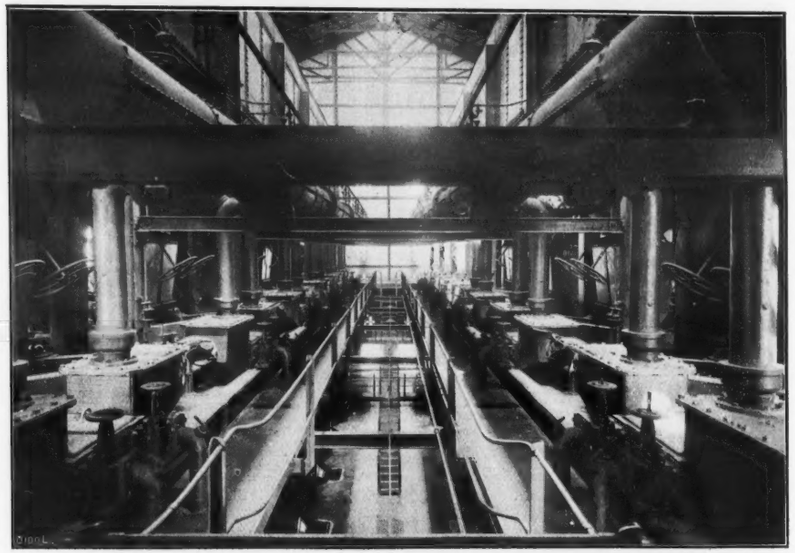


FIG. 52. BENCH TOPS SHOWING HYDRAULIC MAINS, FOUL MAINS, &c.

(*To face page* 229.)

up with coke from the overhead bunkers, and it is for this reason that a supply of coke is provided to each retort as explained above. A charge of coal is then admitted to the container, and as the extractor gear gradually removes the coke from the bottom of the retort, the coal descends and fills the upper portion. As soon as gas of the proper quality is being produced, the retort is re-connected with the main and closed up.

The general arrangements for the collection of the gas evolved in the retorts and its delivery into the foul mains can best be followed by an examination of Figs. 5 and 7 on Plate IX *ante*. It will be seen that there are four foul mains, one running along at the back and one at the front of both benches. Each retort is connected to one or the other of these mains through a hydraulic main, and a vertical ascension pipe. The arrangements are illustrated in greater detail in Figs. 28 to 33, on Plate XV, and are also shown in the photographic illustration, Fig. 52, on Plate XVI. The gas first leaves the retort through a tapered off-take pipe of ample cross-sectional area, clearly shown in Fig. 28, and passes through a bend fitted with a self-sealing lid, separately illustrated in Fig. 32, into the hydraulic main. A small trickle of ammoniacal liquor is allowed to enter the off-take pipe, its evaporation absorbing heat and the liquor also serving to keep the interior of the pipe moist and so to collect the dust. The hydraulic main consists of a series of separate boxes, one for each retort, arranged as shown in the plan, Fig. 31, and mounted on a platform well away from the heated brickwork of the bench. The design and construction of the hydraulic main is clearly shown in Figs. 28, 29 and 30, and it will be seen that the gas entering at one end passes over the surface of the liquor and leaves through a dip pipe connected with the ascension pipe. The level of the liquor can be adjusted to seal the dip pipe to a depth of 2 in., a seal of this amount being used during scurfing. After scurfing, a slight seal is used until gas of the desired quality is being produced, and the liquor level is then gradually lowered until there is no seal and the vacuum is controlled by the retort-house governors; the normal working level of the liquor is about 2 in. below the end of the dip pipe. At the end of the hydraulic main opposite to that at which the gas enters, a self-sealing cover is provided for cleaning purposes, as shown in Fig. 30. The seal regulating valve, which is 4 in. sq., is shown on the left of Fig. 28. The liquor overflow and the tar collected in the hydraulic main pass through this valve into short vertical tar pipes, and thence through an inclined tar main, of which there are four in all, to underground storage tanks outside the retort house. The tar pipes and mains, which are 6 in. in diameter, have spigot and socket joints and the mains are fitted with cleaning boxes at intervals, as indicated in Fig. 5 on Plate IX *ante*. Details of the seal-regulating valve and its connections are illustrated in Figs. 28 and 33, while the former shows a plug fitted, for cleaning purposes, in the bend connecting the valve to the tar pipe.

The ascension pipes leading the gas from the hydraulic main to the foul main, are 8 in. in diameter, and are fitted with Peet's valves to enable each retort to be completely cut off, apart from the seal previously referred to. The foul mains are of riveted steel-plate construction, and are 18 in. in diameter. As shown in Fig. 5 on Plate IX *ante*, they slope upwards in the direction of the flow of gas. A dribble of liquor is led through a visible feed into the foul mains near the connections to each retort, and this liquor, which runs back into the hydraulic mains, serves to keep the internal surfaces of the pipes wet, and thus to remove a considerable proportion of the impurities from the gas. From what has been said above it will be seen that the gas is in contact with wetted surfaces from the moment it leaves the retort, and this has the important effect of dissolving—before they become protected by a coating of tar—any crystals of ammonium chloride formed. The two foul mains from each bench are connected to 8-in. governors situated in the corner of the retort house at the bench top level, as shown in Figs. 5 and 7, on Plate IX *ante*. The governors are in duplicate, working in parallel, and they reduce the suction, equal to a 3-in. column of water produced by the exhausters, to a pull of about $\frac{1}{10}$ in. of water at the retorts. Each governor is mounted on a seal pot so that any thick tar which may be deposited in the necessarily restricted passages through the governor can be readily removed. The exhausters and purifiers employed form part of the original installation, and call for no particular comment.

In our previous article, we mentioned that the coke formed in the retort is supported at the bottom on a reciprocating plate or tray, from which it gradually falls into a closed receptacle, and we now propose to describe this part of the installation more fully. Figs. 8 and 9 on page 167 *ante*, show the general arrangement of the extractor gear, which is illustrated in greater detail in Figs. 35 to 48 on Plate XV. Reliability in working is obviously of extreme importance in connection with the mechanism, since the proper working of the retorts is dependent upon the regular removal of the coke as the carbonised charge descends. Other important desiderata are silence in working and the prevention of breeze formation, all of which appear to have been satisfactorily secured in the Dempster-Toogood design. In this, the extractor proper consists of a smooth inclined tray of cast-iron having renewable steel-plate liners, on which the coke rests at its natural angle of repose. The tray is given a slow reciprocating motion by mechanism, which will be described later, and, as it moves, a part of the coke which is left unsupported falls into the receptacle, whence it is removed at intervals through a vertical door. One of these doors, which are of the self-sealing type with asbestos joints, can be seen in Fig. 34 on Plate XV, and this illustration also shows the travelling filler by means of which the coke is delivered on to the gravity-bucket conveyor. The maximum dimensions of the space through which the coke passes are 5 ft. by 1 ft. 2 in., and since there are no claws or guide vanes to restrict the movement, there is no possibility of the largest formations interfering with the process of extraction. The tray, as shown in Figs. 35 and 37, is supported on two rows of 6-in. cast-iron balls, the balls, five of which are provided in each row, running on the edges of two parallel ridges formed on the back of the tray and also on the edges of two fixed steel flats. Details of the ball paths are illustrated in Fig. 39.

The form of the coke receptacle is clearly shown in Figs. 35 to 38, and details of the mechanism for imparting a slow reciprocating motion to the trays are illustrated in Figs. 41 to 48. In this connection we should first explain that running along the whole length of the benches on each side, and at the level of the extractors, is a small rolled-steel joist. This joist, which is shown in section below the grooved friction wheel on the right of Fig. 41, and in elevation in Fig. 42, is suspended from swinging arms, one of which is indicated by dotted lines in Fig. 42. The joist is given a longitudinal reciprocating motion by means of crank pins and connecting rods, the former being mounted on the ends of transverse shafts situated at the ends of the benches. One of the shafts referred to is illustrated in Fig. 20, on Plate XIV, and this shaft is driven at a speed of $10\frac{1}{2}$ r.p.m. by belt and worm-reduction gearing from a $4\frac{1}{2}$-h.p. electric motor, shown in Fig. 19 on the same Plate. At the other end of the benches similar transverse shafts with crank pins and connecting rods coupled to the reciprocating joists are driven by a $3\frac{1}{2}$-h.p. gas engine, so that the drive can still be maintained in the event of a failure of the electric supply. The stroke of each of the joists can be adjusted independently between zero and 8 in., by varying the throw of the corresponding crank pin, according to requirements, and under normal working conditions the joists make twenty-one $4\frac{1}{2}$-in. strokes per minute.

At each retort, the joist is connected by a pin joint with a pair of cast-iron levers, shown in Figs. 43 and 44, the levers being pivoted on a shaft carrying a grooved friction wheel. Eccentrically mounted on the free ends of the levers is a circular pawl, the edge of which fits into one of the grooves on the edge of the friction wheel, so that when the joist, as illustrated in Fig. 43, moves to the right, the friction wheel is turned in an anti-clockwise direction. The motion of the friction wheel in the opposite direction on the return stroke of the joist is, however, prevented by a second pawl fitting into the other groove on the friction wheel; details of the pawls, both of which are similar, are given in Fig. 45. The inner end of the shaft of the friction wheel carries an adjustable crank pin, detailed drawings of which are reproduced in Figs. 46 and 47, and this crank-pin is connected by a link to the end of a lever, the other end of which is fitted to the square end of a shaft passing through stuffing-boxes in the sides of the coke receptacle under the retort, as shown in Fig. 35; Fig. 40 shows the stuffing-box in detail. Inside the receptacle, two levers keyed on to the shaft, as shown in Fig. 35, are each connected by a pair of cast-steel links, illustrated in Fig. 48, to the coke-extractor tray, to which a reciprocating motion is thus imparted. The stroke of the tray is usually about $4\frac{1}{2}$ in., but this can be adjusted independently for each retort by means of the crank pin shown in Fig. 46. The time occupied by the tray in performing a complete cycle of its motion is about three minutes, but this is dependent upon the speed and stroke of the reciprocating joist which can be adjusted as explained above. It should, perhaps, be pointed out here, although this may have been noticed in examining Fig. 42, that the drive for the extractor gear of each of the adjacent retorts forming a pair, is taken from the reciprocating joist in opposite directions of its motion. Thus, half the extractors of the retorts on one side of the bench are operated on the out-stroke of the joist, and the other half on the return stroke, thereby equalising the driving effort required. Another point in the design which may be referred to before leaving this part of the installation is that by disconnecting the operating links from the extractor tray, the latter can be allowed to run down to the lower end of the ball track so as to leave a clear opening up through the retort, as will be seen from Fig. 42. This feature, of course, facilitates the inspection of the interiors of the retorts.

The coke which collects in the receptacle falls with little or no assistance when the door is opened at intervals of about $2\frac{1}{2}$ hours, into the hopper of the movable rotary filler illustrated in Fig. 34, the filler serving to load it into the conveyor buckets uniformly and without spilling. As mentioned in our previous article, the coke as it leaves the receptacle is practically cold, its heat having been utilised in heating the primary and secondary air supplies to the system, so that no quenching is required to prevent re-ignition. The ashes from the producers are dealt with in a simple and expeditious manner, which calls for but little explanation. They are raked out from the ash pits at intervals by a man working on the floor at the level of the bottom of the benches, and shown in Fig. 49, on Plate XVI. Immediately in front of each ashpit door, a cast-iron grating is fitted into the floor, as can be seen in the illustration, and the ashes fall through these gratings, down inclined chutes, suspended below the floor, as shown in Fig. 50, into a wagon running on a standard gauge track on the ground floor of the retort house. The last-mentioned illustration also shows the walking way provided to give easy access to the coke-extractor gear described above. Similar walking ways are provided between the benches and the retort-house walls, as can be seen in Fig. 19, on Plate XIV.

(To be continued.)

ACTON CAR REPAIR SHOPS OF THE LONDON UNDERGROUND RAILWAYS.

(Concluded from page 202.)

In our previous article on the Acton Car Repair Shops of the London Underground Railways, we stated that we intended to reserve till this week an account of the wheel and tyre section of the shops. This section is particularly complete, and is fitted with several interesting tools. The machines and processes are again arranged with a view to definite routing of the work which, however, is a little complicated on account of this consisting naturally both of re-turning as well as complete re-tyreing of wheels while different methods of fixing the tyres to the rims also involve trouble to some extent. In general, wheels and axles coming from the stripping bay are first inspected, and it is then decided what course they should follow. Close to the

incoming point are all the facilities for attending to axles, and for stripping, if need be, the wheels of their old tyres. Two modern 200-ton presses are also available if the motor gears or wheel centres have to be taken off their axles. The tyre-boring section is complete in itself, and the arrangements for re-tyreing are also laid out so that this can be very expeditiously done, the retaining ring and stud work being handled close by. The wheel-turning lathes are in a section to themselves, served by a 3-ton overhead travelling crane.

Close to the entrance point of the wheel and tyre section is a new journal-turning and burnishing lathe by Messrs. Craven Brothers (Manchester), Limited, of Stockport. In this lathe the axle is housed in a central head stock fitted with gap pieces. For journal turning two end slide rests are employed, while opposite these at the back of the lathe are arranged upper and lower burnishing rollers. The work of re-turning and of burnishing may thus proceed without interruption or delay due to changing tools, &c. In the centre of the lathe on independent pillar bases are two compound slides which are used for turning off the lip of old tyres to release the retaining ring, so that the tyres may be taken off. This machine is driven by a 10-h.p. motor, with 3 : 1 reduction.

Supposing the tyres to allow of returning, the wheels are sent on to the wheel lathes. In this section, a general view of which is given in Fig. 37, are four wheel lathes, each driven by an independent electric motor. Two of these have each a 50 h.p. motor, with push-button control for the starting panels, one of which is of the Brookhirst solenoid pattern and the other a Metropolitan-Vickers panel with a small motor for operating the starter. The Craven lathe to which the latter is fitted is provided with two face plates 3 ft. 11 in. in diameter and two front tool rests. The lathe is arranged with adjusting rams and split collets, so that the axle can be gripped by the journals instead of merely being held by point centres. It is also fitted with wedge side grip drivers. The loose headstock is traversed by a separate 7 b.h.p. motor with quick locking gear; this expedites considerably the setting up of wheels in the lathe.

If the tyres are past returning, the retaining rings are taken out, after the lip has been turned off in the above lathe, or the bolts and studs removed and the tyre is heated on a gas ring for removal. New tyres are bored in the tyre-boring section in which are several modern machines, including a duplex Webster and Bennett mill, and Gisholt, Stirk and other mills. This section is served by a series of small pneumatic fixed radius cranes. One crane serves two machines. These little cranes are very handy and are easily managed by one man who can, without assistance pick up tyres and place them on his machine or remove them after finishing. They are well illustrated in Figs. 52 and 53, page 240, and in Figs. 38, 39 and 40 annexed. The main parts consist of a steel column, over the upper part of which fits a sleeve combined with the jib. Close to the sleeve, inside the jib casting, is a cylinder in which works a piston, to the rod of which is fitted a rack. This vertical rack meshes with a small pinion on a shaft laid along the top of the jib. At the outboard end of the shaft is a small reel on to which are wound two light wire ropes to which the lifting hooks are attached. The action of the piston in the cylinder is controlled by a valve coupled to a control rod run horizontally under the jib and terminating within easy reach of an operator standing under the winding reel. The man using the crane thus has the control always within reach and as the jib is slewed the control accompanies the movement. The floor at this part of the shop is covered by these cranes and is marked off with white painted circular arcs struck from the crane centres to help in depositing work within reach, &c. One of these circular arcs is well shown in Fig. 53. It is further planned to facilitate movements by the installation of a roller gravity conveyor so that the rough tyres will be more readily brought to the individual cranes and the finished ones disposed of.

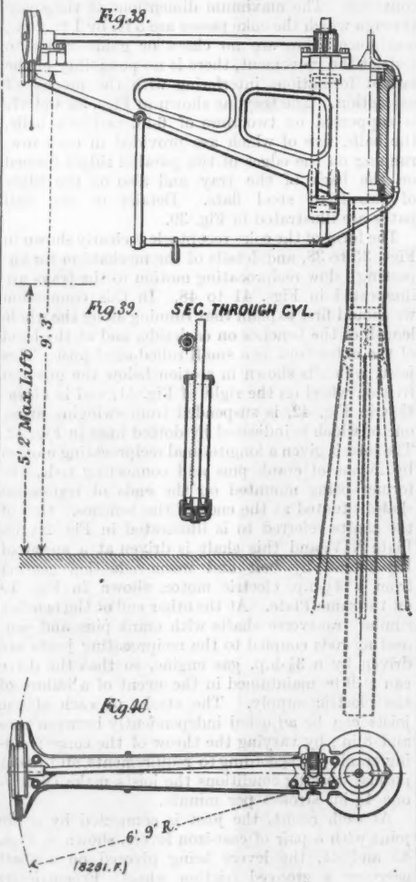
The most recent addition to the tyre section is a new mill by Messrs. Craven Bros. (Manchester), Limited, of Reddish, Stockport. This machine has the advantage of not being encumbered with top hamper in the way of standards, cross-slides and boring bars projecting over the chuck. Setting up and lifting off work is thus considerably expedited. At the same time the several adjustments are centralised just above the work as will be clear from the view of the machine in the Acton shops, given in Fig. 53. This particular machine is for tyres from 2 ft. 8½ in. to 4 ft. on the tread. The machine consists of a circular base supporting a central casting on which are two low standards carrying compound slide rests. Around this central part is arranged a large revolving ring which serves as a chuck. This is driven by worm and worm wheel, on the shaft of the latter being a pinion meshing with an internal gear ring on the lower part of the chuck ring. The drive installed at Acton is by electric motor. Hand adjustments are provided for the tool boxes, as well as automatic feed both vertically and horizontally. The feed motion is derived from a gear ring on the inner diameter of the chuck. This is in mesh with gears on vertical spindles housed in the standards and from which the two feeds are derived. The amount of feed can be varied while the machine is running. The tool boxes are arranged for multiple tooling, and with both heads suitably tooled the boring of tyres is very expeditious even when complicated by recessing for lips and retaining rings.

The only parts projecting sideways from the columns are two hand wheels. These are made to take off very readily for putting on or lifting off work. The tyres are supported on three strong rests fitted with hinged clamps. The latter can be quickly fastened, or released and thrown clear. The machine is driven by a 15 b.h.p. motor with 3 : 1 reduction gear. The operating time of 2½ hours per motor tyre obtained at Acton in ordinary working speaks well for the machine.

The bored tyres are transferred from this section to the tyre heating furnace area, where a very interesting installation is to be seen. This consists of two Oerlikon electric tyre-heating furnaces. General views, of these two furnaces are given in Figs. 41 and 42, while a small diagram showing the lay-out is given in Fig. 43. From the latter it will be seen that the two furnaces and two floor plates are arranged under a revolving jib crane, which also, within its working circle covers the gas ring previously mentioned for removing old tyres, and two or three machines, including the journal burnishing lathe, described above, a special drilling machine and other plant. The two furnaces consist of portable heaters of the Oerlikon standard type, converted into fixed machines in so far as they have been surrounded by and built

THE CAR REPAIR SHOPS AT ACTON.

FIG. 37. WHEEL TURNING SECTION.



CAR REPAIR SHOPS OF THE LONDON UNDERGROUND RAILWAYS AT ACTON.

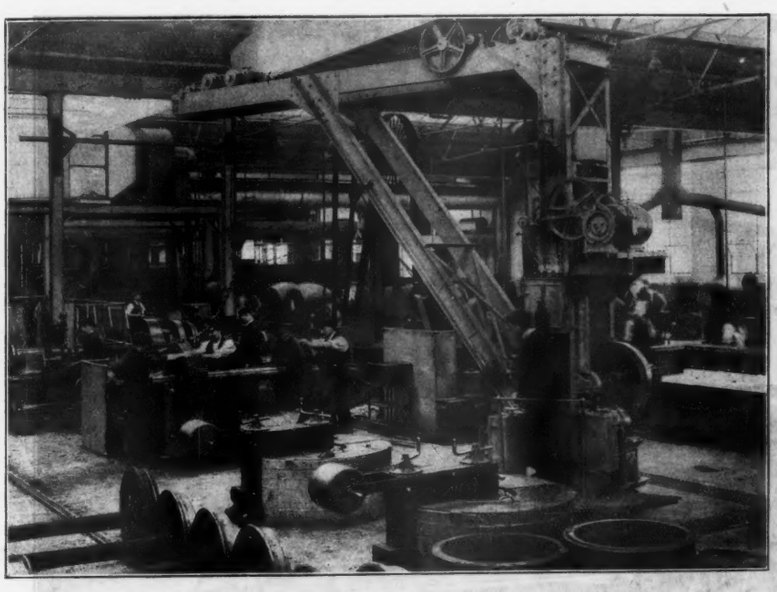
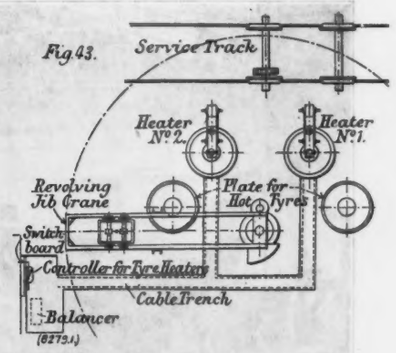
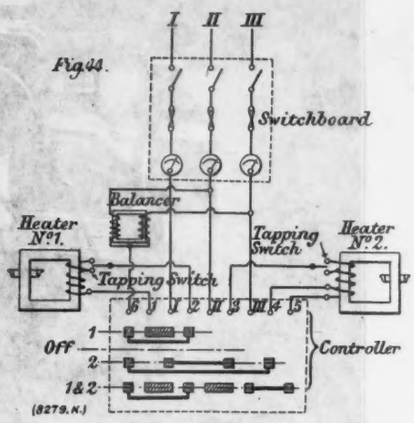


FIG. 41. THE OERLIKON TYRE-HEATING FURNACES.

FIG. 42. HEATED TYRE BEING LIFTED FROM FURNACE.

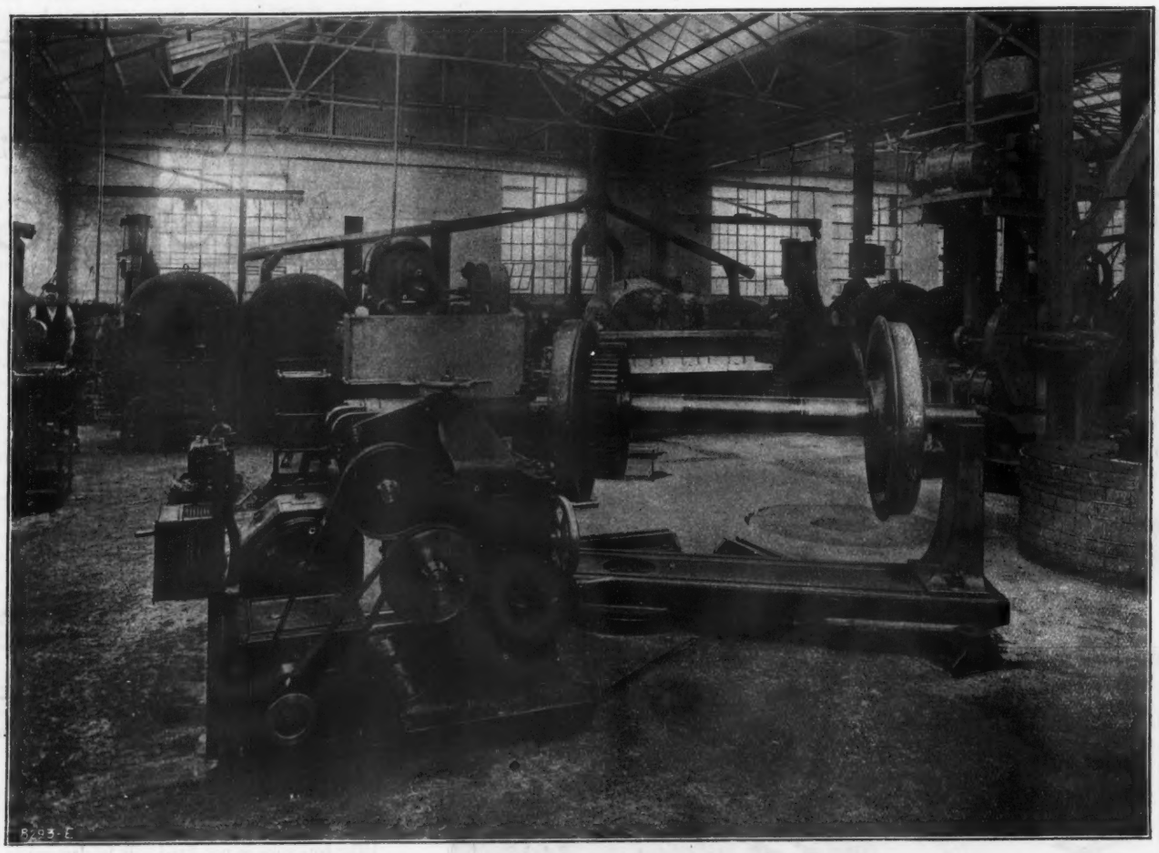




into circular brick walls to conserve as much as possible the heat generated. The Oerlikon machine consists of a transformer composed of two vertical limbs and top and bottom yokes of thin laminations, a primary winding being arranged on the vertical limbs in the centre of the furnace. When in position, surrounding this, the tyre becomes a secondary winding of one turn and carries a heavy short circuited induced current which heats it rapidly. The top yoke is not fixed. It is clamped in place by two long screws which pass through the vertical limbs to the bottom yoke. These are fitted at the top with large washers and long handles in order to enable them to be screwed well down to secure a good circuit. One of these screws is shown in the foreground of Fig. 42, in which the top yoke of the near furnace is seen swung partly to one side. When swung quite clear a tyre is put in position on the table inside the furance wall, surrounding the central limb as described. The yoke is then swung in again, the screw inserted and tightened up and the current turned on. The machines are each rated at 60 k.v.a. They operate on 3-phase current at 415 volts and 33 cycles. A diagram of the connections is given in Fig. 44, the particular arrangement adopted being required by the fact that the machine is built for use with single phase current. The heaters can be used separately or both together. Heating from 60 deg. F. to about 400 deg. F., the temperature required to obtain sufficient expansion, occupies about 17 or 18 minutes according to the size of tyre. The process is free from all dirt, and heating is uniform throughout the tyre. Under the jib crane to one side of each tyre furnace is a plate fixed in the floor for hot tyres. When ready for shrinking on, the axle fitted with its wheel centres is lifted endwise and swung over the furnace (Fig. 42). Special hooks are hung from the lower wheel centre, and these pick up the tyre in the furnace. The axle, wheels and tyre are then hoisted and swung over one of the floor plates. In lowering out, the tyre first rests on the floor, the hooks are removed and the wheel centre follows down into the tyre in one operation, instead of the tyre being first handled and then the wheels picked up and lowered in. The saving of time effected is valuable and makes it possible to work to lower temperatures in the furnace without fear of too much contraction occurring before the centre is finally placed.

The next process is dependent upon whether the wheel centre and tyre are of a pattern requiring retaining rings, studs or bolts. For drilling and

CAR REPAIR SHOPS OF THE LONDON UNDERGROUND RAILWAYS AT ACTON.



[Fig. 45. Drilling and Tapping Machine for Retaining Studs and Bolts; Messrs. Craven Brothers (Manchester), Limited.

tapping for retaining studs, bolts or rivets, a machine by Messrs. Craven, Brothers (Manchester), Limited, is used. This is shown in Figs. 45 and 46. The machine itself is most clearly seen in Fig. 45, in which a pair of wheels is shown on the movable carriage beyond. Fig. 46 shows in the foreground the movable carriage, and gives a good idea of the drilling head. The chief feature of the machine is its adaptability to three kinds of work, viz., to drilling retaining bolt or rivet holes transversely across the rim, or drilling and tapping for retaining studs set either directly radially between the spokes or at an angle to the rim. The wheels to be drilled are mounted in half bearings on the carriage, one end of which rests on a turntable while the other end swings over two slotted beds set at an angle to each other, to which it can be clamped in any position, by means of dogs. This allows the rim and tyre to be set as required with the axle parallel with the drilling head, or at right angles to it, or at an angle for angle studs.

From Fig. 46 it will be observed that the drill itself is set at right angles to a drilling head which can be fed in and out in its horizontal housing by means of the large horizontal hand wheel at the top of the machine. This drilling head and housing can also be traversed across the machine on a large horizontal slide, this movement being controlled by hand by the hand wheel on the facing side of the machine in Fig. 46. This movement constitutes the feed. Power feed is also provided. No vertical adjustment of the head is arranged. The drill is driven by means of small gears and a spindle revolving inside the extending head. The tool is provided with a 7 b.h.p. constant speed motor running at 710 r.p.m., and two speeds are arranged, one for drilling and the other for tapping.

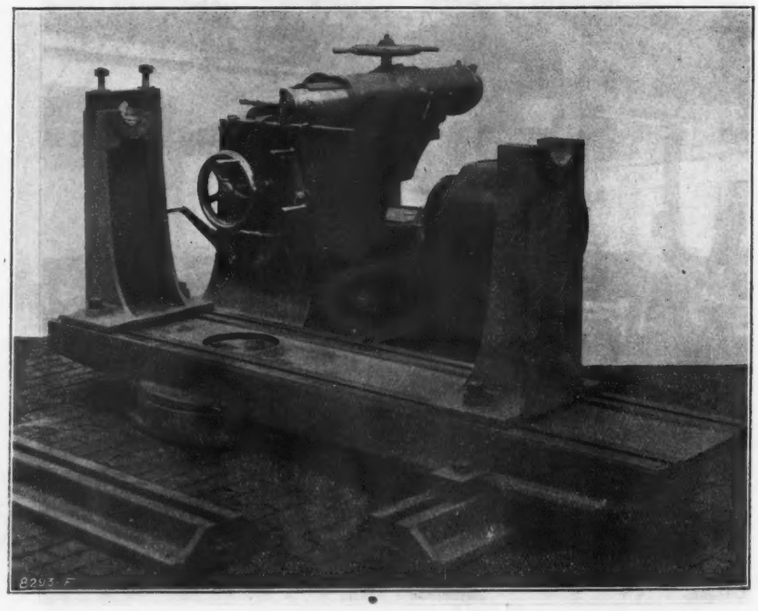
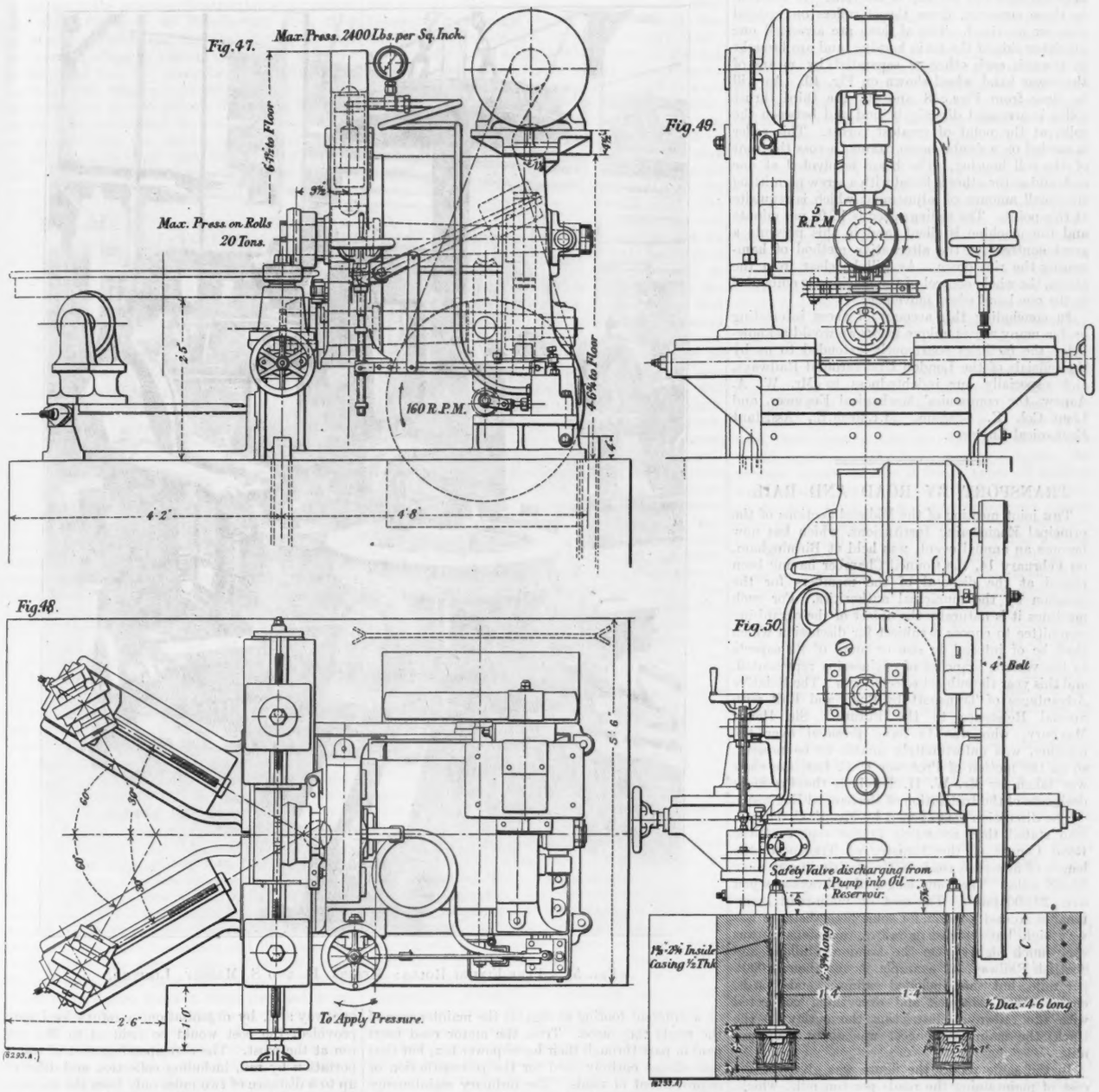


Fig. 46. Drilling and Tapping Machine for Retaining Studs and Bolts; Messrs. Craven Brothers (Manchester), Limited.

If the wheels are of the retaining ring type, the ring is fitted and the lip is then rolled down on the rolls illustrated in Figs. 47 to 51. This machine is by Messrs. B. & S. Massey, Limited, Manchester, and is sometimes preferred to the more usual hammer type of machine, particularly for modern high-tensile tyres, in which case the material is liable to fracture

CAR REPAIR SHOPS OF THE LONDON UNDERGROUND RAILWAYS AT ACTON.



when hammered down cold. The main feature of the machine consists of two shafts fitted at the ends with rolls. As will be clear from the illustrations, the tyre is gripped between these rolls, and pressure is exerted on the upper one by means of an hydraulic ram. The machine is driven by an electric motor of 10 h.p. The drive from the motor is by belt to a main pulley 3 ft. 6 in. in diameter mounted on a worm shaft running across the base of the machine at the rear. The worm on this shaft gears with a large worm wheel on the lower roll shaft, which runs in fixed bearings. The upper roll shaft is driven by gearing from the lower shaft as will be seen in Fig. 47. The upper shaft is carried in trunnion bearings at the back of the machine, well shown in Figs. 47 and 50, and is further carried at the front end in a bearing arranged in a vertical guide housing, inside which the pressure ram is placed. The latter, and its cylinder, are fitted with ball ends, working in sockets, in the underside of the housing crosspiece, and the top bearing, respectively. A heavy counterbalance is fitted to the top roll, operating on a shaft running across the machine and exerting an upward pressure on the bottom bearing of the top roll. This cross shaft of the counterbalance is connected on the opposite side of the machine to the link and screw gear shown well in Fig. 47.

On release of the screw gear, the counterbalance lifts the top roll, and a tyre can be inserted. On running the nut up the screwed shaft by means of the hand wheel, the vertical link raises the counterbalance and the top roll descends on the tyre. When these are in contact further screwing of the nut in the same direction converts the vertical link into a fulcrum for the horizontal lever, which then acts on the control or bye-pass valve of an oil pump at the back of the machine. The amount of movement permitted is adjustable by means of a screw and lock nut. This pump forces oil by means of a coiled pipe into the ram cylinder, as shown in Figs. 47 and 50, drawing its supply from a reservoir in the base of the machine. The pressure exerted on the top roll can be raised over a wide range up to a maximum of about 20 tons. The pump itself is driven off the worm shaft, and is always running when the machine is in use.

The machine can be used for wheels mounted on their axles or otherwise. Fig. 51 shows a pair of wheels slung from the crane and illustrates how the one under treatment is supported by two adjustable rollers carried by radial beds, in addition to the bottom roll. These adjustable rollers are well shown on the plan, Fig. 48, their position being set to suit the diameter of tyre being worked. The machine at Acton will take wheels up to 4 ft. 6 in. in diameter on the thread, or down to a minimum

of 2 ft. The arms of the bed will be seen to set 60 degrees apart, while the axes of the rollers make an angle of 120 degrees, with 120 degrees between each and the axis of the rolls. In addition to these supports, three thrust rollers on vertical axes are provided. Two of these are arranged one on either side of the main housing, and are brought in towards each other or separated by means of the lower hand wheel shown on Fig. 49. As will be clear from Figs. 48 and 49, the third thrust roller is arranged directly behind and between the rolls, at the point of greatest thrust. This roller is carried on a double beam running across the front of the roll housing. The beam is pivoted at one end, and at the other is fitted with a screw permitting the small amount of adjustment which is requisite at this point. The rolling speed is 15 ft. per minute and the machine is silent, and in this presents a great contrast to the alternative method of hammering the rim down. As will be clear from the above, the whole control of the machine is embodied in the one hand wheel movement.

In concluding this account of these interesting and in many senses unique works we would acknowledge the facilities courteously extended to us by the officials of the London Underground Railways, and especially our indebtedness to Mr. W. A. Agnew, the companies' Mechanical Engineer, and Lieut.-Col. E. Graham, M.I.Mech.E., Assistant Mechanical Engineer.

TRANSPORT BY ROAD AND RAIL.

The joint meeting of the Midland Sections of the principal Engineering Institutions, which has now become an annual event, was held at Birmingham, on February 14, the Council Chamber having been placed at the disposal of the members for the occasion by the municipal authorities. For such meetings it is naturally the object of the organising committee to choose a subject for discussion which shall be of interest in one or more of its aspects to the various branches of engineering represented, and this year the subject selected was "The Relative Advantages of Transport by Road and Rail, with Special Reference to the Future." Sir Henry Maybury, who was to have presided over the meeting, was unfortunately unable to be present, so on the motion of Professor F. C. Lea, the chair was taken by Mr. W. H. Patchell, the President designate of the Institution of Mechanical Engineers.

The discussion was opened by Mr. E. C. Trench, who stated that according to the report of the Road Census of the Ministry of Transport, the length of first-class roads in Great Britain was some 22,000 miles. The route-length of railways was just over 20,000 miles. The cost of main-road maintenance around London, for some little distance was very high, but the cost of railway maintenance was very much higher. On the London, Midland and Scottish Railway, for example, it was about 1,000*l.* per mile, but that included sidings, goods yards, engine sheds, stations and everything connected with the railway. Restricting the outlay to the track, the maintenance cost was about 600*l.* per mile.

In the same report the figure was given of the cost of maintaining the roads per ton mile, which, decreased as the tonnage increased. The figure given was somewhere between 0·32 and 0·3 of a penny. How that compared with the cost per ton-mile on the railways he did not know, because the statistics were not available, but he imagined that the cost would be a good deal less than the above figure. Man power for maintaining the railways was round about one man per mile, of single track. He should think that was not far away from the labour power employed on the roads.

It seemed to him that what the railways had a right to ask for was fair play. They had two or three grievances which they would like to see removed. One was that they were expected to pay for the roads over their bridges, and the approaches to the bridges—roads which were made by them for the benefit of their competitors. In the second place, they thought the railway companies ought to have as much right to use road transport as anyone else. Thirdly, they thought it was not quite fair that their competitors should be on a different footing as regards the maintenance of the roads they used. True, the motor road users paid in part through their horse-power tax, but that was almost entirely used for the reconstruction or improvement of roads. The ordinary maintenance of roads was paid for by the ratepayers. He suggested that if they were going to put the two systems on an even footing the road transport companies ought to pay for the maintenance of the roads. It seemed to him that the only way it could be done was by a petrol tax. Sixpence or sevenpence per gallon tax on petrol did not seem to be an outrageous tax to suggest, and it would pay for the maintenance of the roads, as far as damage was done by the petrol-driven motors.

Mr. H. H. Humphries, the City Engineer and Surveyor of Birmingham, devoted some time to a historical consideration of road transport. He pointed out that although road transport could not generally compete with rail transport over very long distances, yet for certain classes of goods it could successfully do so. For instance, the freight of a 10-ton load of small machinery parts from Birmingham to Manchester, including the loading at the works and unloading at the destination, was 28*s.* per ton, which was for loading only one way: if, by organisation, a return load were provided, the cost would be reduced to 25*s.* per ton at the most. The corresponding cost of transportation by rail, including collection and delivery up to a distance of two miles only from the stations, was 30*s.* 5*d.* per ton, and there would appear to be no doubt that as road transport traffic improved—as it, of course, would—the competition for long-distance traffic with railways would increase for a large proportion of goods to be transported.

One of the vital features, however, in connection with the future of road transport appeared to be the necessity of setting up efficient organisations to prevent, as far as possible, one-way loading, and this necessity was becoming so patent to commercial lorry users that there was but little doubt that ere long it would be universally arranged. It was stated that with the recent lowering of the railway charges, motor lorries could only operate economically within a radius of about 50 to 60 miles, in connection with transporting the majority of goods. This, to a large extent, would probably always obtain as regards certain classes of goods, and it was in connection with such a small radius activity that the importance of co-operation between railway and road motor transport arose.

THE CAR REPAIR SHOPS AT ACTON.

Fig. 51. Tyre-Fixing Rolls; Messrs. B. and S. Massey, Limited.

It would have been noticed that a deputation from the Commercial Motor Users' Association recently waited upon the Ministry of Transport in opposition to the proposed construction of the motorway from Coventry to Manchester, when they submitted statistics showing that during the last two years haulage by road in cases of 60 miles per journey was now the exception. Mr. Humphries expressed the opinion that the opposition to the motorway was almost entirely due to the fear that should it be constructed the local Authorities would not proceed with the making of new trunk roads or improving existing ones, which would tend to drive the lorries on to the motorway, with consequent payment of tolls, which it was desired to avoid.

If the greatest benefit was to be derived from railway transport, the railway companies must work in with town planning and re-planning schemes in connection with industrial areas, so that far more use could be made of direct loading from works and factories into railway trucks. Far too little attention appeared to be paid to the question of running siding branches through suitable areas in such a way that branches might be taken into works and factories so as to enable direct loading to be effected. Whether it would be possible to evolve a vehicle that might both travel on rails and be taken from them and then drawn along the roads would seem to be a matter worthy of careful consideration.

Sir Henry Fowler said in facing the problem he was compelled to ask, what work had they to do on the road compared with what they had to do on the rail? He had spent many years working out this question of resistance on railways. On the previous night, in his capacity as an automobile engineer, he presided at a meeting of the automobile engineers, and in dealing with features in certain cars reference was made to 70 lb. to 100 lb. per ton, as resistance, on a level road. Advantages in running upon rails included that of a much lower resistance. As to fuel, the old price of petrol worked out at about ½d. per ton mile on the road. On his section of the railways they had improved on that with engines with which he had something to do with building; the coal used was 0·069 lb. of coal per ton mile, and that figure had since been beaten. One-sixtieth of a 1d., as compared with a halfpenny used in other traction! The congestion of road traffic and the irritating difficulties of movement at crossings in London, and in the central parts of Birmingham, Liverpool and other cities were a matter of common knowledge; and personally he thought it would be better if there were no horses on the roads, at any rate, in such districts. Then there was the personal fatigue of motor-car travel; the advantages in this regard, as well as in comfort, were certainly on the side of the railways. As to the latter, there were, of course, disadvantages; in some towns, like Cheltenham and Worcester, the chief station was some distance from the town. Railway rates would have been cheaper but for the action taken during the war, when they had to pay wages higher than they ought to have been called upon to pay. As a result of the award of the Industrial Court, the shopmen received 6s. 6d. more than the amount paid in motor shops. In spite of that, he believed the railways were right from the standpoint of cheapness. There was not the slightest doubt that there was room for each form of traffic. The railways would always remain as the removers of bulk traffic whether of goods or passengers. They had to deal with goods in terminals at the end; and, despite the suggestion that the railways were not sufficiently mobile, a larger amount of goods traffic was going to the railways. A tremendous advance had been made by means of control systems with the result that there were more certain movements of goods traffic. The railway companies were constantly making improvements. Experimental locomotives were being built, and the improvements made in the last few years were inadequately appreciated. Moreover, he believed that the size of the truck would grow; there would be lighter construction with regard to passenger vehicles.

Professor Burstall said he could not speak with regard to the practical problems of transport by road and rail, but he would venture to lay before them certain general principles.

First of all, what was the real great advantage of railways as at present constituted? It was twofold. First, the bearing surface was hard, it was something in excess of 140 on the Brinell scale. In the second place the rail was elastic. It bent between its supports on the sleepers. It was not possible to conceive of heavy density, high-speed traffic going along a road unless they could devise a road which more nearly approximated in the accuracy of its construction to the iron way. At the present time the petrol vehicle was approximating to a remarkably sound mechanical job. But it had one terrible defect, which seemed to have escaped not only the notice of speakers that evening, but he had observed it was rarely alluded to by the manufacturers of petrol vehicles. He referred to the raw product of petrol itself. He laid it down as a general principle that for one country to depend upon another country for its raw material in such an important matter as traction was profoundly wrong. They had practically to import every drop, not merely of petrol, but the middle and heavy oils, and that was why he had repeatedly urged not only automobile engineers but oil-engine builders that they should not throw all their weight into an engine which could only be operated by imported oil. He should like to give them certain information, which, of course, was well known to those who had studied the subject. It was mainly found in a very well-known book, Poe's "Economics of Petroleum," by a great American economist, published in 1922, which dealt with the position of petroleum from the American point of view. The writer prophesied that there would be a moderate scarcity of kerosene or petroleum in 1926, but a famine in 1930. Again, they must bear in mind this fact, which was not often dwelt upon, because it was not pleasant. America had got all the petroleum in the world if she wanted it. They were using at present 80 per cent. of the petroleum of the world, and they were producing 70 per cent. They were increasing their motor cars and trucks at a perfectly inconceivable rate; and he thought that that was a real point which should be borne in mind in connection with all matters concerning road transport. If it were possible to devise a cheap and efficient coal burning, steam propelled road vehicle the whole position would be altered, except from the point of view, as Sir Henry Fowler observed, that both for speed and density it was not possible, or probable, that any road transport system was ever likely to be equal to the iron way.

Sir Philip Dawson said he thought that transport by road, canal and by air must be co-ordinated with rail transport if the best system were to be devised. As to the improvement of transport methods on railways, he believed we were on the eve of very great developments. The introduction of electric haulage involved a most radical change and it would be a long time, probably, before it became more or less general, though some progress had been made, particularly on suburban lines. They had to confess that such electrification was done under the stress of competition, which from omnibuses and tramcars had become acute. It was difficult to bring home to the railway companies the idea that a large amount of their long distance passenger traffic might be filched from them, unless they adopted improved methods of traffic in connection with their long distance lines. He was afraid it was a fact that if there were advantages in connection with the grouping of companies, there were also disadvantages. He did not think it could be denied that in consequence of such grouping the electrification of railways had been postponed for a considerable period. Some time ago it was stated by the Great Eastern Company, that it was their intention to electrify their suburban system around Liverpool Street, but he understood that the scheme had been postponed and that nothing in that connection might be expected for some time. He believed it was true to say too, that the postponement of the proposal by the North Eastern Company to electrify their main line from York to Newcastle, was due to amalgamation, and the same reason might, he thought, be given for the deferring of the idea entertained by the London, Brighton and South Coast Company of electrifying their suburban system and their main lines to Brighton, and possibly as far as Hastings. In main line electrification substantial progress had been made in Europe, as elsewhere, but he preferred to quote Europe, because the conditions which obtained there more closely approximated to those in this country. In round figures it would be found that Europe had 6,000 km. of railway routes electrified or in course of electrification, and that 9,200 km. represented projects, while the number of locomotives operating or under construction was 1,400. It had been said that the only countries in the world where railway electrification had been successful were either those where mountain ranges had to be traversed, or where large water power was available and where coal was difficult to get. It was however, quite an erroneous statement that great developments in electric railway traction had not taken place except where there was hydro-electric power. He was told that the electrification scheme at Leipzig gave a return of 15 per cent. on the capital. When comparisons were made between steam traction and electric traction, several important items were often left out of consideration as applying to the latter. Great saving was effected by reason of the fact that they did away with pumping water towers, purifying stations, coal and ash-handling plant, and with much transportation of coal to various depots. Turntables would also be dispensed with, and in crowded centres important economies of space would be affected. It had been estimated that a palatial hotel could be built over Liverpool Street station if steam were done away with, thus releasing land, the capital value of which would represent 5,000,000*l.* sterling. Again, the average speeds of the different types of haulage were brought into much closer range for passenger, goods, &c. With steam there were seven speeds between Newcastle and York; by electrification the figure could be reduced to three. The mileage per hour was considerably increased, and at the same time the cost per ton-mile was considerably reduced. He suggested that it would be good policy to spend 50,000,000*l.* sterling on electrification for the reasons he had mentioned, and also because the work involved would go a very long way in saving the payment of doles. What was essential at the present time was big-scale operations in matters of this kind. The Newcastle to York line and the London to Brighton line might be commenced at once. His hope was that that would be done.

Mr. H. Jackson, of the Birmingham Corporation Salvage Department, gave some particulars relating to the operation of the electric vehicles used for refuse collection by the Birmingham Corporation. The decision to adopt such vehicles in place of horse-drawn carts had been due to the introduction of the 48-hour week, which necessitated a more rapid method of dealing with the work. The power required for charging the vehicles was very largely supplied by the cinders and combustible material in the refuse collected.

Mr. Richard Humphreys, in opening the general discussion, remarked that electric tramways had been ignored in the debate, but he felt that they could not and should not be ignored. They could show the advantages of the rail, about which Professor Burstall had spoken, and they could also show the advantages of the road. Tramways had not been given a fair show, but he considered they could still justify their existence. The burden of road maintenance in future had got to be shared among all the users of the roads, and when that time came he felt sure that electric traction would have a new lease of life.

Mr. George Lanchester (speaking for the automobile engineers) said their branch of the engineering profession and of the great transport services had been spoken of very severely. He could only plead youth; they were a very young industry. The magnates of the railways had referred to them rather caustically. They had only been in existence about one-third of their period, and to-day the motor development was somewhat analagous to the railways' position 60 years ago. On the whole, he thought the comparison was favourable to the new industry. Every speaker was agreed that the necessity to-day was for co-operation, and the fact that the automobile engineers had been invited to that gathering was a good omen for the future. Petrol taxation, he would remind Mr. Trench, had already been tried, and it was a failure, the reason being that if they

taxed petrol the automobile engineers at once set to work to use some other fuel, and the revenue suffered. The question of taxation was a very difficult one, because there was one thing certain, the country had got to find the money to improve the roads, and it could only be done by taxing the users. How that was done did not matter, because the money had to be found, and every alteration in the tax probably meant an increase. Road transport users did pay for the roads to-day, or, at any rate, for a very large proportion of the upkeep of the roads. The cost did not fall with equal justice on all classes of road users. At the present time the private car owners were the scapegoats and had to bear the greater share of the tax. They did not complain, because it operated to keep the cost of transport of goods down. As to speed of transport he admitted that the railways with some justice could claim to be faster on long journeys, although he knew of journeys from Birmingham to South Wales and Bournemouth, for instance—which could be done faster by road than by rail. There were two or three factors which would reduce the cost of road transport. Undoubtedly the improvement of road transport vehicles would continue. They were rapidly making improvements, and they would continue to do so, just as the railway engineers were doing. Then improvements on the roads would be a great factor in reducing the cost of transport.

Professor F. C. Lea thought two points had not been sufficiently emphasised—that of co-operation on the one hand, and the significance of town-planning on the other. In the future it would be necessary to consider the arrangements of the areas located to industry with respect to the main line railways, and the arrangement of sidings in and near works to ensure the easy handling of goods. If something like that were done for all heavy traffic, it would be better to develop in that direction than in the direction of road transport. In regard to town planning it would be necessary to consider the type of traffic to be used for carrying the workers to the residential areas.

The policy in Birmingham had been to improve roadways largely in order to provide work for the unemployed. It was important to ask the question whether we were doing right, not only from the immediate point of view of providing employment, but from the view point of future policy, whether it would not be better to expend—he did not say 50 millions of necessity on electrification—but a substantial sum in perfecting our railway system and putting into work large numbers of skilled workers rather than in spending huge sums in the development of the roadways.

Professor Cramp remarked that this country was built up of a large number of comparatively small towns which were for ever extending, with the need for the proper collection of goods. His view was that any system of goods distribution which was tied to a particular road was bound eventually to disappear. That would mean that every vehicle must eventually carry its own source of power. There was then another question: was the motive force necessary, to be supplied by the electric accumulator or by mechanical power such as petrol storage, the latter giving economy in space and weight? At the present moment petrol held the position. We must look forward to some electrical process for the storage of energy in its most economical form. Development would be along electrical storage lines.

Major Thompson recalled that Sir Eric Geddes, when Minister of Transport, indicated that in his mind it was settled that rail was the transport for long distances and road for short distances. No detailed reference has been made in the discussion to steam transport by road. He had heard from a large haulier in the district that with a steam wagon and trailer he had hauled a full load 78 miles, and that his average fuel cost per day with a steam lorry was only 3 cwt. of the best Welsh coal. It would not be easy for either the petrol people or the railway people to beat that figure of cost for moving heavy traffic over short distances.

Major Cook (Ministry of Transport) said Mr. Trench was under a misapprehension in saying that the road users paid nothing towards the maintenance of roads as distinct from the improvement of them. During the current financial year 9,000,000*l.* of the revenue collected from the local taxation was devoted to the maintenance of roads pure and simple. That was something like 75 per cent. of the total amount collected as a result of motor taxation, and he thought the tendency was for the proportion to increase. It was only fair to say that during the current year probably one-third of the total cost of road maintenance and improvements in this country had been derived from motor taxation. He quite appreciated that it was a sore point with the railway companies that they should be saddled with the maintenance of roads over bridges. It was a liability which the legislature had imposed upon them and they had accepted it. Changing conditions had made that liability rather greater than was probably originally anticipated, but there never had been a case put up to the road department of the Ministry, whereby the local authorities had made an arrangement with the railway company to release them of the maintenance of those road sections, subject to the railway company paying something approaching the cost of what they would be relieved of without the case having been put through. So Mr. Trench must agree that there was every desire to act squarely with the railway companies in that sense. It did not seem to him that there could be any question of competition, as far as the highway authorities were concerned, between the railway companies and the roads. On the other hand, each surely had its function to fulfil; one was entirely complementary to the other. As far as the Ministry of Transport was concerned, any application which was put forward for the classification of roads leading to railway stations, especially goods stations, on the ground that the traffic over the road was particularly heavy owing to the presence of the railway, was quite favourably entertained. Many miles of approach roads to railway stations were classified on that account. It must be remembered that of the whole of the roads in the country, out of the motor taxation 50 per cent. was paid for the maintenance of Class I roads, and 25 per cent. to Class II roads; and there was every indication that the proportion of expenditure defrayed by road users, as compared with the proportion paid by the ratepayers, would tend to increase.

With regard to the question of expenditure on unemployed relief work on roads, it was only fair to say that that work was for the most part defrayed also from the proceeds of motor taxation. So there was no question of any advantage being derived by road users at the expense of the railway companies.

Replying to the discussion, **Mr. Trench** said he was glad that a broad view had been taken of the subject as a whole. He did not think they had spoken unkindly of the automobile people. They had each their own functions; they had got to live and let live. All the railway companies asked was to be allowed to live. The Ministry of Transport representative had put him right as to the figures of motor taxation. After all, the repair of roads came to something like 4½ millions, and the balance had to be paid out of the rates. The railway companies were large ratepayers, in some cases paying more than all the other ratepayers put together. All he asked for was a "square deal."

Mr. H. H. Humphries said he thought all the speeches tended to one end, namely, that all kinds of transport must work in conjunction with each other. He believed road engineers were prepared to face the problems mentioned by Professor Burstall, and he was hopeful that the experiments now going on would lead to good results.

The Chairman, in closing the debate, referred first to water transport, and said they could not afford the time lost on goods transported by canal. After a reference to the American street railways, and the enormous growth of motor traffic in that country, as a big factor in building up a transport system, the Chairman observed that it was obvious that this country had a long way to go in that direction before approaching the stage reached by America. Surely they should look upon the motor-cars as transport feeders until they could afford tramways; and then trams until they could afford a railway service. In New York, the Chairman also mentioned, a very large amount of delivery work was done by storage battery lorries. Hydro-electrical power schemes were advancing rapidly in other countries. He hoped it would not be as long as some appeared to think before some of the English railway companies took up in real earnest the question of electric traction. They would find it paid, just as other countries had done. Electrification of railways would give them a higher average speed, and that was what they wanted.

THE EDINBURGH AND LOTHIANS ELECTRICITY DISTRICT.

Details of a scheme constituting the Edinburgh and Lothians Electricity District have been published by the Electricity Commission, and a local inquiry is to be held in the City Chambers, Edinburgh, on March 10, to determine or otherwise the acceptance of the scheme. The first meeting, as a result of which the scheme has been prepared, was held in February, 1922. The scheme constitutes the County of the City of Edinburgh and the Counties of Midlothian and East Lothian as a separate electricity district. It is not, however, proposed to establish either a Joint Electricity Authority or an Advisory Committee, and the proposed administrative arrangements in the district are, we think, of a simpler nature than has been possible in any other area which has so far been dealt with.

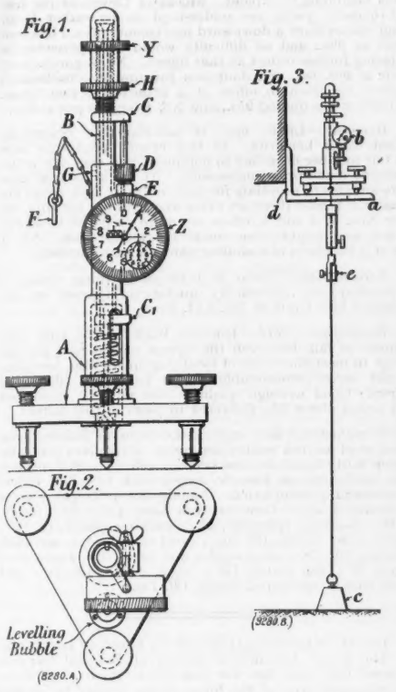
The district is to be divided into two parts, in one of which—which covers the City and Royal Burgh of Edinburgh and the Parish of Newton—the Edinburgh Corporation will be responsible for the supply and distribution of electricity. In the second part of the district all distribution will be in the hands of the Lothians Electric Power Company. This company, however, will purchase all its power at high-tension from the Corporation, which will deliver at four substations to be built at Inveresk, Eskbank, Tranent and Fordel. Supply will be made to these sections by 33,000 volt mains, which may be overhead. All power will be obtained from the new Portobello generating station of the Edinburgh Corporation, which will be extended as required, and the scheme evidently contemplates that this single station shall supply the whole area. The Corporation has smaller stations at Dewar Place and McDonald Road, which are to be utilised in the early days of the operation of the Scheme, but are not to be extended. The company is not to generate power without the permission of the Corporation. Various appeal and arbitration clauses appear in connection with the scheme, to be employed in case of failure of supply and other eventualities, but until the Scheme has passed the test of the second local enquiry and is put into operation it is not possible usefully to comment on them.

Personal.—Mr. Harold Livsey, M.I.Mech.E., has resigned from the position of General Manager of Messrs. John Fowler and Co. (Leeds), Limited. He has been associated with Messrs. Fowlers' business in various capacities for 26 years, and on his resignation the directors have expressed to him their cordial good wishes for his success in any new sphere of operations which he may undertake.—Messrs. Davey, Paxman and Co., Limited, have removed their London offices to Aldwych House, Aldwych, London, W.C.2. Their telephone numbers are City 8860-8861, and their telegraphic address "Paxman, Estrand, London."

The Institute of Transport.—The Annual Dinner of the Institute of Transport was held on Thursday, February 14, at the Savoy Hotel. Members and guests were received by the President, Sir Joseph G. Broodbank, and the function was well attended. The company was fortunate in having as its principal guest Mr. Harry Gosling, C.H., M.P., the Minister of Transport of the present government. Mr. Gosling has been, of course, connected with transport in London practically all his life, mainly in relation to river and port traffic. In proposing the toast of the Institute of Transport (which was virtually a union, and as such helped to bring members together, so that they could better understand the problems which confronted them), he hoped that co-operation would lead to a solution of several matters, including the difficult subject of London traffic. Sir Joseph Broodbank, President, replied to this toast, and was followed in a very entertaining speech by Sir William Joynson-Hicks, P.C., who proposed the toast of the guests. Sir William humorously pointed out that, in view of the vast numbers of people which it was anticipated the Empire Exhibition would this year bring to London, the solution of the London traffic problem was an urgent necessity, or many visitors would never reach Wembley at all. This toast was replied to by Sir Samuel Hoare, C.M.G., who spoke of the recent developments in aviation on the commercial side, recommending transport by air as a subject in which the Institute should increase its interest. The toast of the Chairman was proposed by Sir R. Francis Dunnell, K.C.B., and responded to by Sir Joseph G. Broodbank.

THE METROCLINE.

CONSTRUCTED BY MESSRS. C. F. CASELLA AND CO,, LIMITED, LONDON.



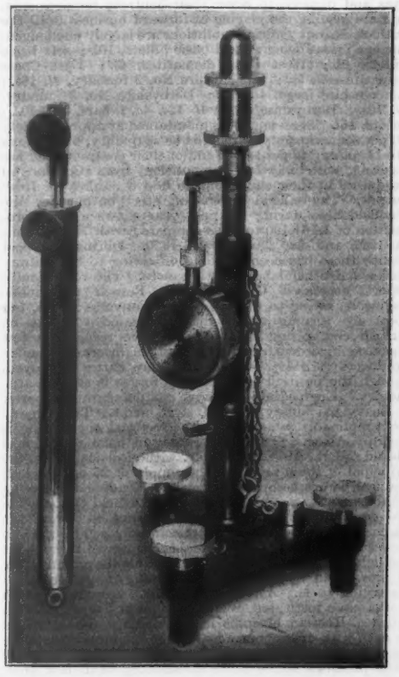


FIG. 4.

THOUGH the contemplated strengthening of several bridges does not give rise to alarm, engineers are aware that many such structures will require overhauling in the near future, and that regular and complete data regarding the strength and safety of bridges and other structures would be desirable. That applies to steel bridges, where the actual stresses arising should be determined from time to time, and certainly not less to ferro-concrete bridges. Accurate tests should be taken of a bridge after completion and records kept for comparison with later tests. Later determination of the strength of concrete structures will otherwise not give any indication of progressive deterioration. Accurate deflection tests would furnish the desired information. That they are not taken as frequently as is advisable, is partly due to the lack of exact instruments of sufficient simplicity in erection and application.

The metrocline, manufactured by Messrs. C. F. Casella and Co., Limited, of 49 and 50, Parliament-street, S.W. 1, which we illustrate by the photograph Fig. 4, and the diagrams, Figs. 1, 2 and 3, is intended to meet this demand of engineers and surveyors. It can be used at any height above the ground level without expensive staging. When more than one instrument are wanted at the same time, in order to ascertain the deflections of a number of girders comprising a single span of a bridge under the passing of a load, each instrument can be set to mark the maximum deflection; thus one operator can look after the several instruments, even if they are far apart.

The instrument, shown in Figs. 1 and 2 in elevation and plan, consists of two main parts, the base A and the deflection rod B, which slides in the vertical pillar standing on the base. In the ordinary practice the instrument should be erected underneath the beam to be examined so that the beam presses the rod B downward, against the upward pressure of a light spring fixed in at the bottom of the pillar. Two pins C and C_1 are permanently attached to the deflection rod; these pins convey any movement in the plane of the deflection rod to the dial indicator Z. The horizontal axis of this dial is so mounted in the pillar that the dial may be turned through 180 degrees and clamped with the boss E pointing either upward or downward by means of a butterfly nut. In the former case the pin C would depress the dial plunger D, moving through the boss E; in the latter case the pin C_1 would come into action. By means of the screw cap D, just sufficient friction can be put on to the plunger to cause it to remain stationary in any position; thus maximum deflection is recorded. The dial Z contains only the necessary gearing. The spacing block, which is shown attached to the pillar by a small chain (Fig. 4), has been added to increase the range of the instrument. For ordinary use the instrument, which is about 1 ft. in height, has a range of $\frac{1}{4}$ in., when deflections are likely to exceed that amount the block is placed on the top of the deflection rod, and the range is thereby increased by $\frac{1}{4}$ in. The larger of the two dials Z is graduated in thousandths of an inch; the small dial indicates the complete revolutions of the large pointer in tenths of an inch.

In cases where it is possible to erect a strong and steady stage for the instrument the dial indicator is used with the plunger pointing upward, as mentioned. The staging should leave 12 in. clear between the instrument and the point of the girder to be observed. The instrument having been levelled, the final adjustment is effected by means of the cap Y to bring the pointer of the dial to zero; it is then locked by means of the milled nut H. The observer watches the dial and notes the maximum deflection. The instrument is not fitted with any recording devices. When the maximum deflection is alone to be ascertained, the cap D is tightened before setting the instrument, as already stated. Where conditions are not suitable for the erection of a stage underneath the girder and for the direct determination of the deflection, some arrangement like that explained by Fig. 3 may be adopted. In many cases it will be possible to find a suitable support on one of the bridge members. If not, an angle iron *a* is fixed to the member, and the instrument *b* is rested on the shelf so obtained. The dial is then turned, first through 90 degrees; the deflection rod is pressed down to its fullest extent and held down by inserting the small pin F into the hole G in the head of the base (Fig. 1). The dial is now turned once more through 90 degrees, so that the plunger points vertically downward. On the ground below a weight *c* is placed in the same vertical plane, and a wire supplied with the instrument, is attached to this weight; the wire is stretched tight and cut off, so that when fixed into the screw shackle (Fig. 3), the hook in the shackle can just be slipped on to the eye in the lower end of the deflection rod. The wire having finally been tightened up by means of the screw shackle, the pin F, so far holding the deflection rod, is withdrawn and the pointer of the dial is set to zero by means of the milled head Y. The deflection can then be determined.

When indirect deflections have to be taken above a running stream, which might deflect a single wire, two weights are used and placed in the axis of the current, the wire *d* being bifurcated at a point above the water level. Observations should be taken early in the morning, and with a cloudy sky, so as to avoid temperature changes during the test. The use of the metrocline is not restricted to deflection tests. The instrument is adjustable to the determination of any small movement in any plane, such as alterations in the length of girders due to temperature changes or the formation of cracks, and the settling of reservoir dams under the head of water.

10,000-R.P.M. ELECTRIC MOTOR.

AN interesting and quite unusual type of electric motor is illustrated in the figure below. The machine, which is of 25 h.p., is built to run at 10,000 r.p.m., being direct coupled to a plant requiring this speed. As will be seen, it is arranged with a vertical spindle. It operates on a direct-current 300-volt circuit, this non-standard voltage being that of the factory in which it is installed. The motor was built by Messrs. Mawdsley's, Limited, of Dursley, Gloucestershire, who have made a speciality of extra high-speed electric motors. The machine has been in use for some time and has performed in a very satisfactory way.

The running of an electric motor at 10,000 r.p.m., introduces many special difficulties which have to be allowed for in the design. Apart from the question of centrifugal forces, difficulties arise in connection with temperature rise owing to the core losses at the high-frequency, while the design of the bearing requires special attention. In the motor with which we are concerned the centrifugal force per pound at the circumference of the armature is nearly four tons, and it will be realised that careful choice of materials is necessary as well as good design, and workmanship. A special form of winding is used, instead of the usual barrel winding, and the ends are brought out close to the shaft, so that the connections from the armature to the commutator are arranged, as far as possible, in a radial plane. The effect is that the centrifugal force results in a longitudinal pull on the wires, and any bending effect is avoided. The wires were soldered into the commutator tags with the hardest solder obtainable, the commutator tags were then turned and insulated with mica and a steel ring was then shrunk on. The commutator has altogether three steel shrink rings.

Temperature rise is kept within proper limits by means of a fan, machined from a solid steel disc, and fixed on the armature shaft. This fan delivers jets of air on to the armature and commutator, and has proved so satisfactory that the temperature rise after a seven-hours' full load run is within the Engineering Standards Association specification limits. The brush gear is of Mawdsley's patent type, in which pressure is applied to the carbon brushes by coil springs. The peripheral speed of the commutator is approximately 12,000 ft. a minute, and close grained electro-graphitic

brushes have been found to give the best results. The commutation is perfect, in spite of the fact that the machine is required to run at speeds varying from 5,000 to 10,000 r.p.m. by means of shunt regulation, so that at the higher speed the field is comparatively weak. The motor thrust bearing takes not only the weight of the armature, but additional weight due to the machine being driven. The conditions are such that the ordinary type of ball thrust bearing proved unsatisfactory owing to the heat generated by the friction of the balls on the cage, and special arrangements had to be made.

BENSON SUPER HIGH-PRESSURE GENERATOR.

TO THE EDITOR OF ENGINEERING.

SIR,—You will no doubt be interested to learn that during the past week-end, the engineering staff of this company, under my direction, and in the presence of a representative of Messrs. English Electric Company, Limited, Willans Works, Rugby, carried out preliminary heat tests on the super-high pressure Benson generator, which was fully described in *Power* of May 22 and 29, last year. The principal features of the Benson generator—that is, the method of steam generation at 3,200 lb. per sq. in., without ebullition, then throttling to 1,500 lb. per sq. in., and superheating—being now generally familiar to most engineers, it is not proposed to discuss the plant in detail, but to give some information regarding the results obtained.

It was considered advisable in the first place to have a covering insurance policy, and a representative of one of the leading insurance companies submitted the generator and pump discharge pipe to a hydraulic test pressure of 6,400 lb. per sq. in., for a period of 20 mins. A special examination was made of the welds and joints, all being perfectly dry with no signs of weakness anywhere. The hydraulic test, therefore, was very satisfactory, and the policy has been issued at a very low rate; in fact, at a rate certainly not more than that of an ordinary boiler rate.

The object of the present tests being only to prove the theory of generating steam without ebullition, and to demonstrate the efficiency of the plant, and also to furnish data for the design of larger and more commercial units, the steam generator only was in operation and discharged directly to a surface condenser against a back pressure valve which maintained a pressure in the superheater elements of about 1,500 lb., special precautions being taken to exhaust to the condenser through an expanding nozzle and partly to cool the highly superheated vapour before it reached the condenser. The initial pressure in the generating heating elements was also maintained constant by a back pressure valve between the generator and superheater, so that while the pressure in the generator was 3,200 lb. per sq. in., the actual pressure in the superheater was 1,500 lb. per sq. in.

The first heat test took place on Sunday, the 17th inst., when the plant actually operated under its own burners for about four hours, the object of that particular run being to tune up only, thoroughly dry out the brickwork and to make the necessary adjustments. The temperature of the fluid was therefore intentionally limited to about 500 deg. F., the pressure of 3,200 lb. per sq. in. being maintained at all times.

A further heat test was carried out on Monday, the 18th inst., with the steam generator in commission about six hours, and the final results were that the pressure of 3,250 lb. per sq. in. was maintained in the generator heating elements at a temperature of 725 deg. F., the fluid on being throttled to 1,500 lb. per sq. in. in the superheater reduced the temperature to 620 deg. F., and the superheater elements raised the temperature at 1,500 lb. per sq. in., to an average of 865 deg. F. Actually at certain periods, a temperature of 910 deg. F. was registered at the superheater outlet.

No apparent difficulties were experienced, and while, of course, it was not possible to ascertain, visibly, the condition of the steam in the superheater, it was obviously highly superheated, the instruments at all times registering a steady reading, the evaporation during the test being over 8,000 lb. of water per hour. While it is not intended at the present time to publish very much information an idea of the very high efficiency obtained may be estimated from the fact that the temperature of the flue gases at the foot of the stack at no time exceeded 110 deg. F., the radiation losses being practically negligible as the generator casing and the ducts to the stack were, by actual contact with the hand, only pleasantly warm. This result would appear to be one of the most remarkable features of the plant; and demonstrates that the efficiency must be exceedingly high. I would also like to add that the high-pressure joints gave no trouble whatever. They have never been adjusted since first being fitted into position.

Regulation of the superheat with a constant evaporation was comparatively easy, and altogether the test exceeded all expectations. It is proposed at a later date to publish the full test figures. We have to thank Messrs. English Electric Company, Limited, for the very valuable assistance which they rendered in the carrying out of these tests.

Yours faithfully,

BENSON ENGINEERING COMPANY, LIMITED.
W. A. JOHNSTON, Chief Engineer.

February 20, 1924.

THE ITALIAN NAVY.—We read in *Le Moniteur de la Flotte* that Signor Mussolini has decided that two destroyers of the Italian naval programme are to be built at Fiume, so as to relieve unemployment at that port.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—From the standpoint of new business the market in raw and semi-finished materials is largely marking time, pending developments in the dock dispute. Steelmakers are buying only sufficient tonnages of hematites and pig-iron to cover their contract requirements, and are leaving the placing of forward business until the outlook clears. Official quotations are largely unchanged, current prices being: hard basic billets, 10*l.*; soft basic billets, 9*l.*; West Coast hematites, 6*l.*; East Coast hematites, 5*l.* 5*s.*; Lincolnshire No. 3 foundry, 4*l.* 16*s.*; Lincolnshire forge, 4*l.* 14*s.*; Derbyshire No. 3 foundry, 4*l.* 15*s.*; Derbyshire forge, 4*l.* 12*s.* 6*d.*; bars, 12*l.* 10*s.*; sheets, 15*l.* Steel output is maintained at approximately 60 per cent. capacity as regards basic quality, but makers are beginning to get to the end of their contracts and are meeting with increased opposition from Continental producers in their endeavour to find a market for fresh output. The official return on steel output for the Sheffield area during the past year shows a total production of 1,164,100 tons, as compared with 719,900 tons in 1922 and 980,200 tons in 1920. During the past month there has been a falling off owing to the railway strike and other labour disturbances. The rolling mills report decreased business with French automobile engineers, owing to the operation of adverse tariffs, but they are turning out slightly increased tonnages on British engineering account and have received a few encouraging orders from agricultural engineers. Foundry producers of heavy steel castings are better employed, though the position at the heavy forges is still unsatisfactory. Engineering concerns are doing rather better in heavy machinery and industrial plant. The demand for supplies in connection with electrical engineering is steadily rising. Sheffield Corporation have this month placed orders valued at 50,000*l.* with electrical firms, the principal of these being for the supply of 25 double-deck tramcar bodies, complete on trucks. Leading engineering establishments in conjunction with Sheffield Corporation are continuing to exert every influence to secure the placing of the cruiser contracts contemplated by the late Government. More active conditions prevail throughout the lighter trades, particularly as regards the manufacture of files, hand saws, hack saws, mining implements and quarrying tools. A few of the most favourably placed works have instituted overtime so as to keep pace with orders. Russian business is spasmodic and is confined to cash-with-order contracts. More engineers' tools are on order for the shipyards. Business in farm and garden tools promises to be more satisfactory than last year. Building trade requirements are in the ascendant. Sheffield Corporation proposes to erect 1,000 houses during the next four years, involving an annual loss at the end of the fourth year of 20,000*l.*, half of which will be borne by the Government. A special feature is to be made at the forthcoming Wembley Exhibition of rustless and stainless metal specialties.

South Yorkshire Coal Trade.—Quotations generally are unchanged, though producers are badly handicapped by circumstances arising from the dock dispute. The shortage of empty wagons is still responsible for irregular working. The continuance of wintry weather has caused a further run on house coal supplies. Merchants have difficulty in satisfying the requirements of inland users. The railways are steadily augmenting stocks against emergency, and there is a strong demand for all descriptions of slacks. Coke is unchanged. Quotations: Best handpicked branch, 35*s.* to 36*s.*; Barnsley best silkstone, 30*s.* 6*d.* to 32*s.*; Derbyshire best brights, 30*s.* to 32*s.*; Derbyshire best house coal, 26*s.* to 27*s.*; Derbyshire best large nuts, 24*s.* 6*d.* to 25*s.* 6*d.*; Derbyshire best small nuts, 18*s.* 6*d.* to 20*s.* 6*d.*; Yorkshire hards, 25*s.* to 27*s.*; Derbyshire hards, 24*s.* to 25*s.*; rough slacks, 12*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 13*s.*; smalls, 7*s.* 6*d.* to 9*s.* 6*d.*

THE NORWEGIAN NAVY.—According to *Le Moniteur de la Flotte*, the Norwegian Navy consists of 4 battleships of about 4,000 tons, 2 gunboats, 3 destroyers, 29 torpedo boats, 8 submarines, 11 mining vessels, 8 auxiliary ships and 25 aeroplanes. The Norwegian Government, adds our contemporary, intends to make its navy consist of the following units: 6 ships carrying armament of not exceeding 1,600 tons in weight, 12 steam-propelled torpedo boats, 26 torpedo boats propelled by internal-combustion engines, 6 large submarines, 8 smaller submarines, 11 mining vessels, about 40 auxiliary ships and 100 aeroplanes. The Government, for purposes of economy, will eliminate the battleships and destroyers.

TRAMWAYS AND LIGHT RAILWAYS RETURN.—A return has been issued by the Ministry of Transport giving particulars of the accounts and statistical returns of the tramways and light railway undertakings in Great Britain for the year ended December 31, 1922, for companies, and March 31, 1923, for local authorities. The tables show that the total route mileage open for traffic at the end of the year was 2,594 miles, of which 1,788 miles were worked by local authorities and 806 miles by companies. The total gross receipts for 1922-23 were 31,264,141*l.*, as compared with 32,523,339*l.* in 1921-22, and the total working expenditure 23,831,523*l.*, compared with 26,835,292*l.*, leaving net receipts amounting to 7,432,618*l.*, or 1,744,571*l.* more than the corresponding figure for the preceding year. The number of passengers carried during the year was 4,349,041,941, an increase of 92,772,549, or 2·18 per cent., as compared with 1921-22. Car miles run amounted to 351,910,233, an increase of 19,830,368, or 5·97 per cent. Of the total car miles run 98·92 per cent. were electric car miles. The return also gives particulars of the working of trackless trolley undertakings in Great Britain.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business is extremely quiet, and is confined to sales for home purposes, the dockers' strike having held up export trade just when it was beginning to expand. Stocks of Cleveland pig iron at makers' yards are understood to be rather large, and values show a downward movement. No. 1 has been sold at 99*s.*, and no difficulty would be experienced in placing further orders at that figure. No. 3 g.m.b. is on sale at 96*s.* 6*d.*, and doubtless favourable consideration would be given to offers at a little below that figure. Foundry 4 is quoted 95*s.*, and No. 4 forge is put at 94*s.*

Hematite.—Little new is ascertainable concerning East Coast hematite. In this branch producers have a fair number of orders to complete, and they are reluctant to make price concessions. At the same time they are anxious to negotiate for new contracts, and values are easier. Whilst there are firms who hold out for 101*s.* 6*d.* for Nos. 1, 2 and 3, offers are quite prepared to accept 100*s.* and might even shade the latter price. No. 1 is at a premium of a shilling above mixed numbers.

Foreign Ore.—There is little or nothing doing in imported ore. Nominally quotations remain on the basis of best rubio at 24*s.* c.i.f. Tees.

Blastfurnace Coke.—Durham blast-furnace coke continues to fall, but even the figures named now are too high to meet the views of local consumers who, however, must derive considerable benefit from the substantial drop. Good average qualities can now be purchased at round about 33*s.* delivered to users in this district.

Manufactured Iron and Steel.—Sales of finished iron and steel are not readily arranged. Producers generally keep fairly busy, but are getting well through contracts on hand, and are keen to secure work to follow orders approaching completion. Among the principal market quotations are: Common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge, and tank plates, 10*l.* 5*s.*; steel angles and joists, 10*l.* heavy steel rails, 9*l.*; fish plates, 13*l.*; black sheets, 13*l.* 5*s.*; and galvanised corrugated sheets, 18*l.* 15*s.*

ROYAL AGRICULTURAL SOCIETY'S SHOW AT LEICESTER.—The Royal Agricultural Society of England has now issued the prize list for live stock, poultry, produce, implements, &c., at the Show of the society to be held at Leicester, from Tuesday, July 1, to Saturday, July 5. The total value of the prizes offered (inclusive of champion prizes, special prizes and medals) is 15,360*l.*, of which 1,632*l.* 15*s.* are contributions from the Leicester Local Committee, 3,185*l.* 6*s.* from various breed societies, and 1,482*l.* 10*s.* from other sources.

BRITISH IRON AND STEEL PRODUCTION.—The National Federation of Iron and Steel Manufacturers state that the production of pig iron in January amounted to 631,500 tons, compared with 626,900 tons in December and 567,900 tons in January, 1923. The number of furnaces in blast at the end of January was 189, compared with 204 at the end of December, 15 furnaces having been damped down owing to the railway strike. The output of steel ingots and castings increased from 653,300 tons in December to 690,100 tons in January.

THE MANCHESTER SHIP CANAL.—The report of the directors of the Manchester Ship Canal Company, to be submitted to the sixty-sixth ordinary meeting of shareholders to be held on the 28th inst., shows that the sea-borne traffic dealt with in 1923 amounted to 5,107,648 tons, the barge traffic 256,292 tons, or a total of 5,363,940 tons. Additional railway accommodation had been provided at Ellesmere Port Docks and at Stanlow. The construction of a reinforced concrete wharf, including foundations for transit-sheds, adjoining Trafford Wharf Road at the Manchester Docks, had been completed, and the wharf was in use. A contract had been let for the construction of the foundations for two reinforced concrete transit sheds of five floors, each of 450 ft. long by 110 ft. wide, on the north side of Dock No. 9. A Bill was being promoted for deepening the portion of the Eastham Channel facing the approach to the canal from the Mersey, and also for deepening the canal from Eastham to the river Gowry.

SOCIETE D'ENCOURAGEMENT POUR L'INDUSTRIE NATIONALE.—On the occasion of the 122nd Anniversary of its foundation, which corresponded with the centenary of its declaration of public utility by the French Government, this Institution held last June a series of meetings in Paris at which the President of the French Republic, various members of the French Cabinet and representatives of foreign institutions took part. The proceedings form the subject of a special Bulletin of over 530 pages, now issued by the Society. Amongst the papers that were read on this occasion the following may be mentioned: "The Reconstitution of French Agriculture after the War"; "The Reconstitution of the Textile Industries in the Liberated Regions"; and a translation, together with photographic reproductions, of several of the original pages in German, of the "Confidential Document written by the German General Staff, dealing with the Industrial Situation in the occupied districts of France." This affords further proof of the systematic destruction carried out by Germany during her occupation of these districts.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

The Trade Position.—Now that the dock strike is an accomplished fact and many ships are left lying idle at the various ports, a general slowing down of industry is anticipated. In many cases the stocks on hand are sufficient to meet immediate requirements and a number of shrewd buyers who looked well ahead are now in a most fortunate position, while, on the other hand, there are many who have unfortunately been caught short. The general concensus of opinion here is that the strike cannot and will not be permitted to be of long duration, chiefly on account of our food supplies. It is a pity that the present trouble should have arisen just when the trade of the country was showing signs of improving, and it is an undoubted fact that industry all over the country was beginning to get round the corner and make a forward step. Concerns dealing in raw and semi-finished material from the Continent will soon feel the pinch and are already inquiring locally about supplies.

Scottish Steel Trade.—It is too early yet to say that the dockers' strike has had any material effect upon the steel trade of Scotland, but although foreign steel cannot meantime be a serious competitor the local outlet for the home product will be improved. The general demand at the moment is not very heavy, but inquiries generally are much better both on home and export account. In the latter case, however, the date of delivery is now the trouble, and may mean some business being diverted to Continental makers. Shipbuilders are gradually increasing their consumption of plates and sections, but a lot of leeway has yet to be made up. Structural engineers who are busy are using goodly quantities of material at present, and their prospects of going steadily for some time are quite satisfactory. Consumers of black sheets are also doing fairly well, and makers are tolerably well supplied with orders for both thick and thin sheets. Prices are without change meantime, but as the foreign competitive element fades a stiffening up may take place in home prices.

Malleable Iron Trade.—There has been practically no change in the state of the malleable-iron trade since last report, and business has not improved. The demand is not heavy, and only some moderate lines have been booked over the week, and the outlook at the moment is rather drab. Prices are steady with "Crown" bars called 12*l.* 10*s.* per ton, d./d. Glasgow.

Scottish Pig-iron Trade.—Business in the Scottish pig-iron trade is rather dull, and the strike of the dockers has put a veto on the export trade for the present. Home buyers are not too active either, and consequent on the state of trade three blast furnaces have been damped down. Hematite iron keeps steady at 5*l.* 8*s.* 9*d.* per ton, d./d. at the steel works, but foundry grades have exhibited a falling tendency recently. This may now be checked somewhat with the smaller production. To-day's quotations are 5*l.* 7*s.* 6*d.* per ton for No. 1 foundry iron, and 5*l.* 2*s.* 6*d.* per ton for No. 3 quality, both on trucks at makers' works.

Scottish Pig-iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, February 16, amounted to 716 tons. Of the total, 694 tons went foreign and 22 tons coastwise. For the corresponding week of last year the figures were 6,732 tons foreign and 180 tons coastwise, making a total shipment of 6,912 tons.

INSTITUTION OF GAS ENGINEERS.—The volume of proceedings of this institution for the session 1922–1923 is now available. It contains the reports of the meetings held in London on February 14, 1923, and in Belfast from June 26 to 28. It is edited by Mr. Walter T. Dunn, the secretary, and is issued by Messrs. E. and F. N. Spon, Limited, 57, Haymarket, S.W.1.

PHYSICAL SOCIETY OF LONDON.—On the occasion of the jubilee celebrations of this society, a reception is to be held on March 20 at 3 p.m. at the Institution of Electrical Engineers, Victoria Embankment; at 3.45 the Guthrie lecture will be delivered by M. le Duc de Broglie; and at 6 p.m. a lecture will also be delivered by Sir Richard Paget, Bart. Meetings are further to take place on the following day, March 21, a banquet being held on Saturday, March 22, at 7 for 7.30, at the Connaught Rooms, Holborn.

"RYLAND'S" DIRECTORY.—The seventeenth edition of this directory is now available. It contains complete information on the companies engaged in the British coal, iron, steel, tin-plate, metal and engineering industries, and in the hardware and allied trades, besides data of a similar nature on British merchant firms and consulting engineers whose specialities are the above. For all these companies, firms and engineers the book constitutes a most valuable compendium and guide; it also forms a most useful reference book for all overseas buyers, and facilitates trade with this country in that it further gives a British alphabetical section containing the names of manufacturers of engineering specialities of every kind. Other sections cover British manufacturers of iron, steel and tinplates, giving capacity, class of manufacturers, hands, analyses and all necessary information. British merchants and exporters are in a separate section; it ends with data on foreign and colonial iron and steel firms. The book made its reputation years ago. It is published by Messrs. Eagland and Co., Limited, proprietors of the Iron and Coal Trades Review, Bessemer House, Adelphi, Strand, W.C.2, at the price of 2*l.* 2*s.* net, bound in cloth.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Coal shipped from the chief South Wales ports in January realised on the average 5*d.* per ton more than that exported in December, and 2*s.* 5*d.* per ton more than that dealt with in January of last year. According to returns of the Customs, 2,277,460 tons of coal were exported from Cardiff (including Penarth and Barry), Newport, Port Talbot and Swansea in January, despite the dislocation caused by the footplatemen's strike, which was 73,982 tons more than in December but 121,000 tons less than in January of last year. The value of last month's shipments at 2,932,645*l.* was 143,402*l.* in excess of that of December, and 121,000*l.* more than that received for the larger quantity shipped twelve months ago. The average f.o.b. price realised for last month's shipments was 25*s.* 9*d.* compared with 25*s.* 4*d.* in December, and 23*s.* 4*d.* per ton in January, 1923. The returns for each port in January are appended:—

From.	Tons.	£	Per Ton.
Cardiff ...	... 1,455,481	1,866,732	25*s.* 8*d.*
Newport ...	... 376,070	488,697	26*s.* 0*d.*
Port Talbot	... 219,753	266,630	24*s.* 3*d.*
Swansea ...	... 226,156	310,586	27*s.* 5*d.*
Totals	... 2,277,460	2,932,645	25*s.* 9*d.*

At Cardiff and Newport the average price per ton was 5*d.* higher than in December, and at Port Talbot and Swansea 1*s.* 1*d.* and 9*d.* up respectively. Shipments from Cardiff were increased by 115,257 tons, and from Port Talbot by 39,475 tons, but from Swansea were reduced by 18,069 tons and from Newport by 62,654 tons. Exports of large coal in January amounted to 1,475,433 tons, which was 39,624 tons more than in December, while the average realised price at 28*s.* 4*d.* per ton recorded an increase of 3*d.* Exports of small coal totalled 742,494 tons, an increase of 45,389 tons, and the average price at 21*s.* was up 1*s.* 1*d.* per ton. On the other hand, the quantity of through coal dealt with at 59,533 tons was reduced by 11,031 tons, and the average price at 21*s.* 1*d.* was 1*s.* 5*d.* per ton lower. In the meantime, although coal loading is proceeding as usual, the coal trade is feeling the effect of the strike of dockers, inasmuch as loading arrangements are being disarranged owing to the fact that vessels which were due to take cargoes or bunkers have been held up at discharging ports. Furthermore, with works on short time, the inland demand has slackened off, with the result that the available quantity for export has been increased. In the circumstances, prices have developed an easier tendency and are on the basis of 30*s.* 6*d.* for best Admiralty large and 22*s.* for best steam smalls.

Colliery Dividends Increased.—The final dividends of three important Welsh colliery companies has just been issued, and in each case they show an increase. The Powell Duffryn Steam Coal Co. Ltd. has declared a final of 7½ per cent. free of tax, making 12½ per cent. for the year, compared with 7½ per cent. in 1922; North's Navigation Collieries (1889) Ltd. recommends a final of 5 per cent., free of tax, making 10 per cent. for the year, compared with 5 per cent.; and the Cardiff Collieries Ltd. recommend a final of 10 per cent. less tax, making 15 per cent. for the year, compared with 10 per cent.

CONTRACTS.—The Tottenham Urban District Council have accepted the tender of Messrs. Vickers, Limited, Vickers House, Broadway, Westminster, for the installation of a complete clinker crushing, elevating, grading, magnetic separating and storage plant, to be delivered and erected at the Council's refuse destructor works, Down-lane, Tottenham, in accordance with the specification drawn up by the Council's engineer. The whole of the plant will be manufactured at Messrs. Vickers' Barrow-in-Furness works.

THE M.G.C. MANCHESTER YEAR-BOOK 1924.—The fourth issue of this year-book is now available. It measures 7¼ in. by 5 in., and contains 172 pages on the industries of Manchester, the information covering the cotton trade, a textile glossary on raw cotton, cotton yarn, cloth, wool, jute, linen. The iron and steel trades of the district are also reviewed, other sections dealing with chemicals and dyes; rubber; timber; the Ship Canal; Trafford Park Estate; transport facilities to and from Manchester, &c. Particulars are given of the different associations, various activities and institutions of the city, followed by biographical notes on prominent men in Manchester and district. The book contains a very clear plan of the town. It is issued by *The Manchester Guardian*.

TRANSFER OF ITALIAN TELEPHONES TO PRIVATE ENTERPRISE.—In connection with the transfer of the Italian telephone system to private enterprise, the Department of Electrical Services of the Ministry of Posts and Telegraphs has formulated a model Deed of Concession on the basis of which the transfer is to be carried out. The provisions of the Deed of Concession in so far as they are a reproduction of those contained in the Royal Decree No. 399 of February 8, 1923, and other laws and regulations at present in force regarding the telephone service are final and not open to any modification. The other provisions may subsequently be altered by the Ministry in such way as may be found necessary. Applications for concessions must refer to any one of four zones in which the country has provisionally been divided, open, however, to such modifications as considerations of necessity or convenience may subsequently suggest. Further data can be obtained from the Department of Overseas Trade, Room 52, 35, Old Queen-street, S.W.1.

NOTICES OF MEETINGS.

NORTHAMPTON ENGINEERING COLLEGE ENGINEERING SOCIETY.—Monday, February 25, at 5.30 p.m., at the Northampton Engineering College, St. John-street, E.C. 1: paper on "Thermionic Valves," by Mr. W. Bond.

THE ROYAL SOCIETY OF ARTS.—Monday, February 25, at 8 p.m., at John Street, Adelphi, W.C.2. Cantor lecture, "A Study of the Destructive Distillation of Coal," by Edward Victor Evans, O.B.E., F.I.C. (Lecture I). Wednesday, February 27, at 8 p.m., ordinary meeting. "The Use of Psychological Tests in the Selection of a Vocation," by Charles S. Meyers, C.B.E., M.D., S.D., F.R.S.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Tuesday, February 26, at 6 p.m. Joint Meeting with the Society of Chemical Industry (Chemical Engineering Group). Symposium on "The Treatment of Water for Industrial Purposes."

THE INSTITUTION OF ELECTRICAL ENGINEERS: North Midland Centre.—Tuesday, February 26, at 7 p.m., at the Hotel Metropole, King Street, Leeds. Paper on "The Design of Apparatus for the Protection of Alternating-Current Circuits," by Mr. A. S. FitzGerald.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, February 27, at 6.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. Paper on "The Fundamentals of Cost Reduction," by Mr. H. Kerr Thomas.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, February 28, at 6 p.m. "The Design of Apparatus for the Protection of Alternating-Current Circuits," by Mr. A. S. FitzGerald, Associate Member.

THE INSTITUTION OF CIVIL ENGINEERS.—Thursday, February 28, 1924, at the Royal Victoria Hotel, Sheffield, at 7.30 p.m., when Mr. W. J. Hadfield, M.Inst.C.E., will read a paper on "Modern Highway Methods."

THE BIRMINGHAM METALLURGICAL SOCIETY (INC.).—Thursday, February 28, at 7.15 p.m., at the Theosophical Hall, Darlington-street, Wolverhampton. Paper by Mr. Th. Teisen, B.Sc.: "Notes on the Development of Producer Gas-Fired Furnaces."

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, February 29, at 7.30 p.m., at 39, Victoria-street. Lecturette: "The Manufacture of the Incandescent Electric Lamp," by Mr. W. A. Rhind, M.I.S.I. (Member).

ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, February 29, at 9 p.m., an address will be delivered by Mr. F. E. Smith, C.B.E., F.R.S., on "Modern Navigational Devices." Afternoon lecture next week:—Thursday, February 28, at 5.15 p.m.: Sir William Bragg, D.Sc., F.R.S., on "Crystalline Structure of Organic Substances" (Lecture IV).

PULVERISED FUEL AT MILWAUKEE.—A series of 36 tests have been carried out on a boiler of 4,680 sq. ft. heating surface, fired with pulverised coal, at a power station of the Milwaukee Electric Railway and Light Company. They were conducted by the fuel section of the Bureau of Mines, in co-operation with the Combustion Engineering Corporation. The results showed that an overall boiler efficiency of from 80 to 83 per cent. was attained. The tests indicated that, with the type of furnace and of burners employed, the most efficient rate of combustion was from 1 to 1·5 lb. of coal per hour per cubic foot of combustion space. Good results, however, could be obtained between the rates of 0·6 lb. and 2 lb. per cubic foot per hour. Combustion seemed to be completed more rapidly if the flames impinged on hot refractory material, but this caused excessive slagging and erosion of the refractory. The efficiency of combustion did not appear to be materially affected by increasing the coarseness of the coal, so that only about 65 per cent passed through a 200 mesh screen. Undried Illinois coal, containing 7 per cent. of moisture, could be burnt efficiently, and the only disadvantage of burning undried coal is its more difficult ignition at the time of starting in a cold furnace. An account of the tests is given in Bulletin 223 of the Department of the Interior, Bureau of Mines, Washington, U.S.A.

WOODEN PIPE CONDUITS.—The dismemberment of the Austrian Empire has stimulated the wood-pipe industry again. The Oesterreichische Holz-Röhren A.G., of Pothlavn, on the Danube, established in 1921, had by the end of 1922 laid down 20 new plants. According to G. Legros, of Bern (*Schweizerische Bauzeitung*, of January 26), the pipes are either finished in sections at the works, or made in continuous lengths on the spot. They are built up like barrels, of staves of white and red pine wood, coiled with iron wire by machinery, coated with hot asphalt and finally rolled in saw-dust to make the surface soft; the sections are up to 5 mm. length and 500 mm. in diameter. Continuous pipes are made with staggered stave-joints and hoop irons. Pipes, 5 m. in diameter, will stand water heads of 40 m., pipes of 0·5 m. diameter bear pressures of 200 m. of water and more. Dilatation joints are not wanted, and sharp curves are overcome by means of iron elbows. Wood does not foul when continuously water-soaked, and acids have lasted 100 years. They offer less resistance to the flow of water than cast-iron. Such pipes have considerable elasticity and are used for hydraulic installations, for water supply and for general water services, both hot and cold. They are, moreover, of small weight and of low cost in countries where wood is plentiful and cheap. Mr. Legros recommends them for use in Switzerland.

CAR REPAIR SHOPS OF THE LONDON UNDERGROUND RAILWAYS AT ACTON.

(*For Description, see Page* 229.)

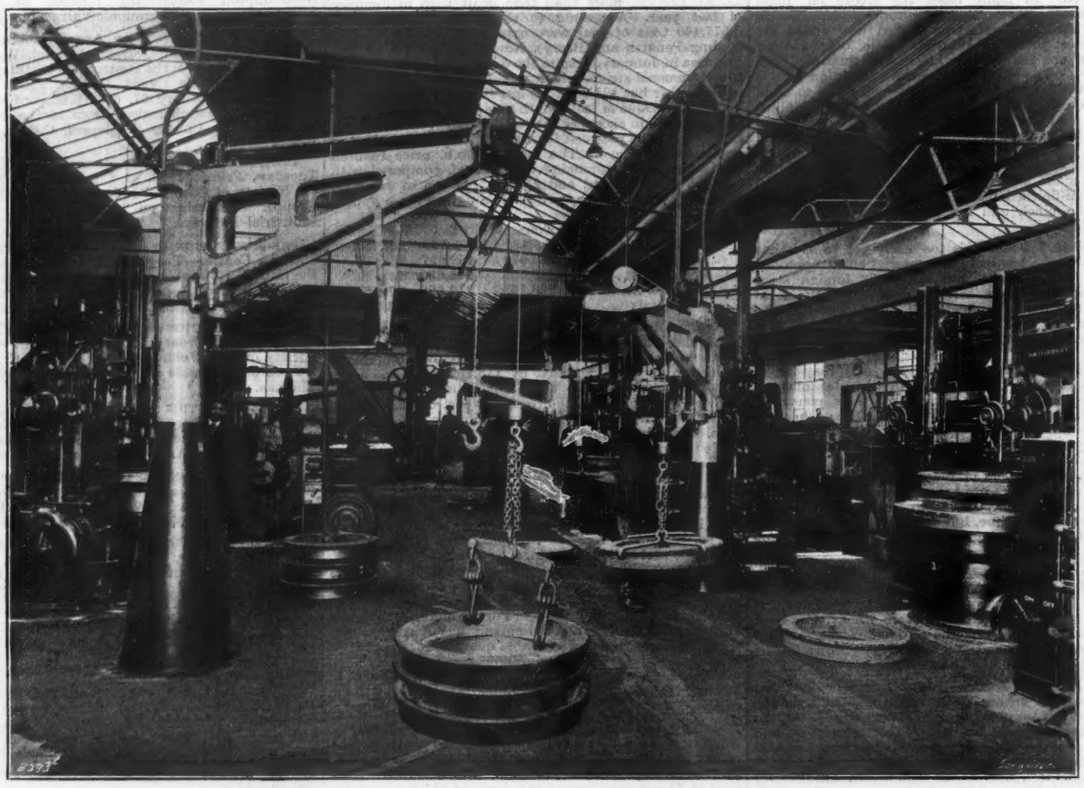


FIG. 52. TYRE BORING SECTION.

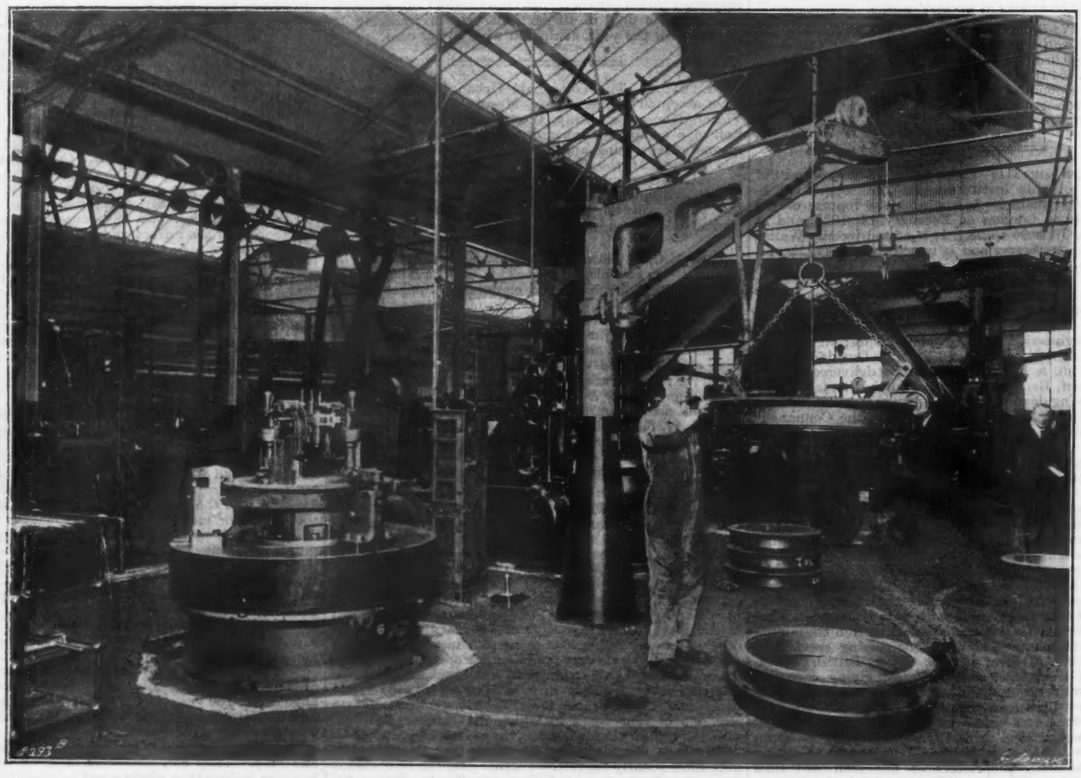


FIG. 53. TYRE BORING MILL; MESSRS. CRAVEN BROTHERS (MANCHESTER), LIMITED.

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One Two-Page Plate and Two One-Page Plates.—*GAS PLANT WITH DEMPSTER-TOOGOOD CONTINUOUS VERTICAL RETORTS AT SWINDON.*

ENGINEERING.

FRIDAY, FEBRUARY 22, 1924.

THE BOARD OF TRADE AND MERCHANT SHIPPING.

THE paper recently presented to the Institution of Engineers and Shipbuilders in Scotland by Mr. F. R. Blair on the above subject has induced more discussion than any other connected with shipbuilding during the past decade. The contributors to the discussion are, generally, men of wide experience in practical shipbuilding, and they, with only one or two exceptions, were unanimous in their opinions that, since about 1912, the officials of the Board of Trade have been acting contrary to their appointed duty of fostering trade, and, actually, that they are embarrassing the British Shipping industry at a time when its position is perilous. The author states that up to 1912 the Board of Trade were a reasonable body, except for the occasional pin pricks which evidently cannot be dissociated from official action, but that a new era began with the loss of the Titanic, which caused them to "lose their heads," with the consequence that they yielded to the clamour of those who were ignorant of the intricacies of ship design and ship management. It would appear that they have adopted, with indecent haste, every recommendation which was put before them, moulded them into official instructions to their surveyors and enforced these instructions without giving interested parties an opportunity of stating their opinions. If such actions had ensured any reasonable guarantees of safety, they would have been well received by shipowners, because, as Mr. A. C. F. Henderson stated, a shipowner has a large amount of capital at risk and will protect it in every way he can; but none of our recent shipping legislation carries with them any reasonable guarantees of safety. The members of the Bulkhead Committee made their position very clear in their report when they stated that "if the damage did not exceed a *specified* amount, and if the *assumptions* in the rules are not materially departed from, the vessel may be reasonably expected to remain afloat." Mr. Blair is therefore correct when he states that the Board is camouflaging the issue to the uninitiated travelling public, by proposing to issue special safety certificates in certain cases, which would naturally be taken to mean that the vessel is unsinkable.

The common causes of complaint against the Department are that the Board of Trade have been dilatory in keeping their regulations up to date, that they will not confer with interested parties on business lines, that they are demanding equipment which is so cumbersome that it could not be fully utilised when the necessity arises, and that they have enforced rules for life-saving appliances and for subdivision which may not provide extra safety, although the latter demand has penalised many good ships to the extent of 26 per cent. of their carrying capacity. There is no doubt that the subdivision laws have caused more irritation than any of the others, for the reason that they are analagous to the recommendations of the International Convention for the Safety of Life at Sea, and these recommendations have not been adopted by any of the international signatories. British shipowners cannot be expected, with finance in its present state, to compete with a penalty of 26 per cent. overhanging them. The most irritating factor in this situation is, however, the fact that the Board of Trade officials have realised for over four years that the present subdivision rules are untenable, and must be revised, and yet they have made no effort to provide the necessary relief until such times as just and equitable rules could be provided.

They seem to have resorted in some instances, however, to the unbusinesslike practice of granting concessions to those who were insistent enough to demand them; and a striking illustration of this objectionable practice is given by Mr. S. B. Ralston in connection with two sister ships built by different shipbuilders; one builder extended the bulkheads to a deck higher than his competitor with a view to meeting printed instructions; the other found that he could meet the latest demands with about 8 ft. less freeboard. When the 1912 Bulkhead Committee was formed, it received a memorandum from the principal officer of the Board of Trade to the effect that any rules regarding sub-division must be of as simple a character as possible, so that they could be put into practice by the surveyors without making or examining calculations of an intricate character. The Committee report shows that this request was not given effect to, because their recommendations were of a most involved and academic nature and totally unsuited for use in a shipyard. While a considerable amount of blame must be attached to the Committee for overriding this reasonable request, an equal amount must be apportioned to the Government officials for accepting them and for allowing the industry to be embarrassed.

Mr. J. Foster King was prominent amongst the speakers on the paper with which we are dealing, and he appears to have been insistent upon the necessity for the present amount of Government control of ship design; unfortunately, however, he does not give any better reason than that "when the whole of the members of the public think the same thing at the same time, legislation must be enforced, and that its composition can be entrusted to the unpaid few who are selected in a more or less well-founded belief in their capacity and also to the permanent officials of the Department." We venture to suggest and remind Mr. King that the demands made at the time of the Titanic disaster were the result of panic, and that if a similar disaster were to occur again, the results would not be vastly different. In any case statistics show that life at sea is remarkably safe, and expert opinion is that no legislation would reduce the amount of loss in extreme cases. Such statistics are sufficient to convince the interested public that Government interference is not warranted—it is unnecessary to tell the public that it is expensive, and very often retrograde.

It is interesting to review the remarks of Dr. Bruhn of the Norske Veritas, on Mr. Blair's paper. He is an authority on most phases of ship design, and, although a mathematician of great eminence, he has always placed the practical side of problems before theoretical considerations. He says—"The factors affecting the safety of a ship are so many and are of so indeterminate a character that it is out of place to lay down any complex rules—I do not think there is any good excuse for the manner

in which the Conference fixed the subdivision arrangements—I took it absolutely for granted that the British Committee would propose rules of some *simple* character—The delegates of the Convention met with a mandate which more or less amounted to orders to see that accidents like the Titanic did not occur again, and they were prevented from saying that the circumstances were so extraordinary that no rules ought to be based upon that requirement." These frank statements represent the calm and considered views not only of Dr. Bruhn, but also of all the International signatories, and they may be taken as the reason why no endeavours have been made by them to ratify the proposals which were so hastily conceived during a time of panic; they appear to be in splendid contrast to the British practice of enforcing every conceivable proposal at a time when our industry might easily be strangled.

Mr. Blair has given prominence to the official practice of making regulations under the powers given them by Section 724 of the Merchant Shipping Act of 1894, and rightly states that if it was the intention, when the Section was drafted, to make the officials absolute dictators it should be repealed at once. That view will meet with general approval by all who carry the responsibility for finance and design, because, under present circumstances, their arrangements are liable to be upset by any regulation which may be put into print without notice or warning.

Some of the speakers on Mr. Blair's paper suggested that all rules pertaining to ship design should be entrusted to registration societies, but we incline to the view that it is unnecessary to have control over ship design in its principles. Control may mean retardation, whereas designers must be given every opportunity to develop new conceptions. Builders who do not supply the best article will not receive orders. Owners who do not provide good ships will not receive patronage. These are the factors which mean far more than any regulations which can ever be enforced, and as soon as these facts are realised and acknowledged our great industry will again prosper. If, however, it is felt that some control is necessary, it should be arranged by creating a large committee representative of all the industries concerned, and its first duty should be to scrutinise and weed out all the present technical regulations and afterwards to see that nothing will be added which will tend to retard healthy development.

CROSS-COUNTRY TRANSPORT.

THE necessity for a form of traction independent of roads, good, bad or indifferent, made itself felt during the war when the carriage of heavy guns and other loads caused rapid deterioration of roads that had been constructed for lighter and less dense traffic. The actual destruction of the roads in places and the need for crossing from part of a road to another showed the importance of means for conveying stores and supplies without dependence on the roads. The difficulties of mud in Flanders, of snow in the Vosges and the Tyrol, rock and sand in Salonika, and desert country further East, presented different problems for motor transport. The Germans were much better prepared for this class of traction than were the Allies, and though the former had neglected to make use of the caterpillar or chain-track as a means of moving heavy armed or armoured vehicles they possessed wheeled tractors of great engine power, very strongly built, and capable of climbing steep grades by the combination of very low gear ratios with a corresponding strengthening of the parts affected by the changes in the transmission gear. The good performance of these tractors and the study of the conditions unfavourable to their work should have some influence on the design of any future tractors that may be required to work only occasionally on the road and to effect service where the road has not yet come into existence.

The wheeled vehicle with a rigid frame suffers from distortion when crossing streams or gullies at an angle and when the wheels on one side have to climb successive obstacles or fall consecutively into deep holes. Not only must the tractor be capable of withstanding the very roughest treatment but the driver also requires experience in the art of "getting there," in avoiding troubles that his eye has become trained to appreciate, and in estimating gradients and resistance to tractive effort of much greater magnitude than occur in other classes of traction. The same tractor, again, may be required to cross sand, rock, earth, pebbles, marsh, streams and snow, each of which requires special features in design, and special training of the driver.

This problem of transport where roads are non-existent has been solved with more or less complete success by several foreign engineers, each taking a different point of view and elaborating a different design to adapt the vehicle to the conditions with which he has had to deal. In this manner vehicles have been evolved that are capable of travelling over snow, even the dry, hard-frozen kind that blows everywhere and forms dunes like sand, over sand whether sharp and binding or round as pebbles, over marsh incapable of carrying any animal, and up hills and down valleys steep in grade and rough in surface. Though these vehicles have been produced for transport away from the road, each is in some sense superior for its particular class of country; one may excel on snow and another on the desert.

It is the great problem of crossing the desert that has troubled the caravan of pilgrims going in faith to Mecca or travelling with merchandise across the Sahara; it appears that the desert itself ages, that its subterranean water-courses sink lower and lower so that the wells become dry more often and the oases shrink; the once well-frequented trade route carries less traffic, and the nomad robbers raid a larger percentage of the caravans as the total diminishes until the route becomes impracticable for the unit of transport, that is, the camel. In fact, any information as to desert travel must at present be dependent on a knowledge of the radius of action of the camel under various conditions of load and country. When definite facts are sought regarding the camel, the product of carrying capacity and mileage possible without supplies shrinks to a comparatively small number of ton-miles. According to various authorities the camel-load is from 3 to 4½ cwt., and he does 20 to 30 miles in the day, also he can travel four or five days without water, so that his radius of action is 80 to 120 miles loaded, and his work of transport from 35 to 45 ton-miles without water; this does not refer to the Mehari or despatch camel that travels with a strict minimum load, but to the loaded camel of the trade route.

Crossing the desert is of very serious interest to several nations, but the two to whom the question should be of the greatest importance are France and Britain. The French colonies in Africa have an area of about four million square miles and some 44 million inhabitants. France, however, is not alone in Africa, and, adjacent to her colonies flanked by desert, are Spanish, Italian, British, Portuguese, Native States and Protectorates that impede free access from one colony to another for trade, administration and development. The British African colonies, apart from Protectorates, are little more than half the area of the French, but they contain as large a population and much less desert. Like the French they suffer from want of continuity, though to a less extent. The area of country is more than made up when Australia is taken into account, and the balance of desert is then on the British side; it is only recently that the transcontinental railway has been opened, connecting West Australia with South Australia, which is evidence that the subject is beginning to be appreciated at its true importance. In this connection it is interesting to compare the densities of populations. The French African colonies have about 11 inhabitants per square mile, the British African 20, while Australia has only rather less than two persons to the square mile.

It has been clear for some years that if an automobile could be constructed capable of crossing sand and rock, the dunes and dried river beds (*wadis*), the boulders and the rock which occur in the desert, and do this with only a reasonable expenditure of petrol and tyres, it would become a serious competitor to any railway scheme. The railway, in a country liable to the Simoom, may be obliterated for a few miles and traffic held up; even in England the line from Lytham to Blackpool has often been blocked by sandstorms. It would be necessary to equip the transahara railway line with stations 20 to 30 miles apart, with quarters for staff, for track inspection and for repair men and to supply water for the whole of the 1,200 miles by pumps and pipe lines. These conditions are totally different from those of Canada or the United States, where a township can spring up round a station. The locomotive, it is true, can haul a heavy train, but for such a huge distance, and for through work only, the railway would probably have to be laid as a light railway, and a speed of only 20 miles an hour could be expected. Moreover, the locating of a suitable route for a railway is difficult in a country where the existing transport has so small a radius of action, for there is a great difference between exploration and route travel from one known well or oasis to another.

The French military authorities* made repeated attempts to run automobiles in the Sahara from 1916, and the first effort that met with any approach to success was the arrival of an automobile at In Salah from Tuggurt (about 450 miles) after 20 days on the route, but, as Commandant Bettembourg said in an article in *La France Militaire*, this was effected (*trans.*) "only by the combined use of planks, shovels, draught camels and elbow grease." In 1917 the time taken to reach In Salah was reduced, two cars accomplishing the journey in 6 days. In 1918 the range of the automobile extended 200 miles south of In Salah. All this, however, was altered by the advent of the belt-track car which enabled the automobile to make long excursions into the desert without assistance and finally, after careful preparation, to effect the crossing of the Sahara in about three weeks. This, however, is not all that the new means of automobile transport achieved, for it enabled exploration work to be carried out by Lieut. Estienne away from the caravan routes. This research revealed a much easier route than those of the caravans. A further development in automobile traction, encouraged by General Estienne, resulted in the design of the 6-wheel motor lorry with twin tyres throughout. With this one-ton light lorry chassis the crossing from Colomb-Béchar to Burrum on the Niger was effected in less than one week. The fact that this was accomplished by wheeled vehicles with low petrol consumption, has opened the way to establishing a system of fast automobile traffic by convoys of three or more cars, following at sight and reporting at telephone stations. The telephone cabin has for some years been in use in this country as an aid to motor travel, and the selector system for calls to and from intermediate stations in common use in America, has been adopted with success in Belgium for train dispatching, as an adjunct to the block system. If one car of a convoy should break down, the crew could continue on the other cars, leaving the damaged car for repair or till replacement could be brought to enable it to run or to be towed to the base for overhaul. A 1-ton car fitted with suitable radiator arrangements and running on wheels should travel about 10 to 15 miles to the gallon, according to the hardness of the ground, and a speed of 30 miles per hour has been attained on the new Sahara route for a considerable distance. A car carrying 120 gallons of petrol and no other supplies except food for the crew could get through by itself with 7 cwt. of goods without depending on depots. If a regular service were contemplated a comparatively small pipe-line would convey all the petrol that would be required for the supply to filling stations placed at a hundred miles or more apart and the running could then be done by cars with petrol tanks of normal size. The reduction of the supply carried to that necessary for covering two stages would then give a reasonable carrying capacity for passengers and goods.

There is yet another class of country in which transport is almost impossible for part of the year, and is rendered more practicable by the advent of winter with frost and snow. Transport under these conditions interests Canada at present, and

* La premiére traversée du Sahara en automobile, Haardt-Audouin Dubreuil, page 10.

will interest Russia (including Siberia) perhaps in the future. Canada has an area of three and three-quarter million square miles, with about 2·4 inhabitants to the square mile. Russia has eight million square miles, of which over one-half is even more sparsely inhabited. The heavy frost solves the question of crossing rivers and the snow renders transport, of a kind, easier than on dry roads.

According to circumstances such transport has hitherto depended on animal power; the horse for short distances in most countries, the reindeer in Lapland and northern Russia, and the dog in the far North. It is the latter form of traction that the automobile should replace. The team of eight dogs actually carried a reserve in the shape that the sacrifice of one or more of the team may enable the driver and remainder of the team to reach the next post. The dog-sleigh is stated to carry some 5 or 6 cwt. of load 25 to 30 miles per day, giving about 7 or 8 ton-miles per day as the transport unit which closely approached the 9 ton-miles per day of the camel in hot climates.

In the case of countries in high latitudes the conquest of the snows by the automobile has proved a most difficult problem, but it has now been solved in various ways. Where the track has been broken in lumber districts steam chain-track log-haulers have operated successfully. More recently snow-motors have been devised which propel themselves over deep snow by forming screw threads in the cylindrical depressions produced by the driving drums in advancing over the surface. The belt-track automobile has afforded another means of crossing snow at over 20 miles an hour, and experiments made in the Alps and Pyrenees have shown the capabilities of this method. For development, prospecting, administration and the mail service, as well as for the carriage of valuable furs and some other classes of goods, motor transport over snow will probably have a great influence on the future of the boreal regions.

In Britain it is difficult to find large desert areas and the provision of snow is by no means regular, though there are large areas in the North of Scotland where snow is generally available in winter, but to which access is difficult owing to want of hotel accommodation within easy distance. For experiments on sand there are numerous expanses of dunes on the coast, as well as inland patches of which the Long Valley, only 30 miles from London, is a good example. But for testing grounds over really rough country it is necessary to go to Wales or to the Lakes.

Probably the nearest approach we have to the conditions of roadless country is to be found in the desert area of about 65 square miles to the south-east of Llanfairfechan embracing the Carnedds, two mountains which are only of slightly less height than Snowdon. In mid-Wales there is a large tract to the south-east of Trawsfynydd, and further south the Carmarthen Van mountain stands in the centre of a large roadless area. These places are little known to tourist, automobilist or mountain climber; better scenery, better approach and better sport being obtainable elsewhere, but for tractors destined to deal with great natural difficulties these districts may prove to afford good testing grounds.

At a time when motor transport across snow was problematical, an attempt to use the motor sledge was made by the Scott Antarctic expedition. The importance of mechanical traction in the future for the army has not been properly recognised in Britain, though, before the war, Germany was far better equipped. Since the war the military authorities in France and Italy have appreciated the importance of this branch and encouraged progress, while America has advanced the design of commercial vehicles suited to Colonial work. The apathy shown by the military and the manufacturers in this country to a question so vital to our Colonies and Dependencies leaves only the one remaining hope that, perhaps, as in the case of the conquest of the air, sport will join hands with engineering in the evolution of transport for the maintenance of order, the carriage of valuable products and the effective development of the roadless regions.

UNBALANCED RUDDERS OF TWIN-SCREW SHIPS.

DURING the last two years a great amount of experimental work has been conducted at the National Tank on questions relating to the manœuvring qualities of ships as affected by the types of rudder in use. The first paper giving the results of this work was presented to the Institution of Engineers and Shipbuilders in Scotland by Messrs. G. S. Baker and G. H. Bottomley last March (see ENGINEERING, vol. cxiii, page 364). In that paper the phase of the subject treated was the actions of unbalanced rudders on single-screw ships. Since then, further test work has been conducted in relationship to twin-screws, and a paper on this section of the investigations was read by Mr. G. H. Bottomley at the meeting of the Institution of Engineers and Shipbuilders in Scotland on Tuesday last. In this later work the form of ship used for the earlier investigations was retained, and thus the only changes introduced were those incidental to the alteration of the propeller arrangements. As no screw aperture was necessary with the twin-screw equipment, it was filled in with a flat metal plate. Spectacle frames and bosses to take the screws were fitted to the model, and the propellers were connected through gearing to a motor placed inside the model. The tests generally were conducted with four different forms of rudder, two of which had the stern edge vertical, but were of different widths, while the other two were of a form approaching a triangle, but set in the one case with the wide part well down in the water and, on the other, with the wide part at or near the water level. In addition, a further series of tests were conducted with a similar triangular one of greater width to determine the effects of propeller race. The tests were conducted generally at two speeds corresponding to 8 and 12 knots respectively for the ship, the revolutions for each speed being noted from a tachometer attached to the propeller shafts. When propelled at these revolutions, the model was towed by the tank carriage as the rudder was put over, and all measurements of rudder forces and turning movements were then made.

From the results it was seen that the triangular rudder with the major part of its area near the water line gave a marked drop in the pressure on the rudder and in the couple of the water forces acting on the ship just before she began to move off her course, which was known as the ship turning moment. This seemed to support the conclusions of Mr. Foster King, which he based on experiments he conducted in 1902, with a series of triangular rudders. In his tests it was noted that when rudders with the broad part at the water line were used on twin-screw vessels the results showed relatively greater loss than in the single-screw vessels. The distribution of the area so that a large part of it was swung into the race of the propeller as the rudder was put over increased both the pressure and the ship turning moment. Another deduction from Mr. Bottomley's tests was that the forward movement of the water at the stern due to the ship, reduced the torques and pressures on the rudder, which were obtained at the ship speed in open water, roughly by 45 per cent. The observed effect of the twin propeller races on the rudder was very small, and, in fact, almost negligible until the rudder had been put over to about 25 degrees. At 30 degrees of helm the increase of ship-turning moment over the value when the screws were not working was not more than 12 per cent., which was very small compared with the 100 per cent. change shown in the single-screw tests. The corresponding increases in rudder forces and torques were also very small.

The changes in the rudder torque and ship-turning moments produced by increasing the diameter or pitch ratio of the propellers were also found to be very small, and shifting the propellers to other positions nearer or farther from the hull had no effect, which indicated that the pressure increase due to the screws was the same in the race column for some distance aft, but it was not yet known at what distance the thrust would begin to drop. Experiments were conducted by Mr. Bottomley to obtain a comparison of the effects produced when the screw propellers turned inwards or outwards. These showed that when the propellers turned inwards the torque and pressures on the rudder were increased by roughly 15 and 20 per cent. for 15 and 30 degrees of helm respectively, and the ship-turning moment was increased by from 5 to 9 per cent. over those obtained when the propellers turned outwards. It must be recognised that to take full advantage of this increase in ship turning moment involved the use of greater stress on the rudder stock of the unbalanced rudder. With the propellers placed in open water behind the fin plate, there was practically no difference between the effects of outward and inward turning. Tests were also conducted to determine the effect of closing the screw aperture of the rudder. When the screws were not working, the only differences between the single and the twin-screw ships were the screw aperture and the bossings. If twin screws were used, the only effect of closing the rudder aperture was to prevent the stream lines passing through it and enable the rudder, when put over, to hold water against the deadwood. When the screws were idle, this filling in increased the rudder pressures and torques by 20 and 25 per cent., and the ship-turning moments by 50 and 55 per cent. for 15 and 30 degrees helm respectively. No experiments were conducted to determine the effects of the bossings, and it was consequently not known to what extent the results were attributable to their presence.

With the twin screws working behind the model, it was shown that the race effect was small, whilst behind the single screw vessel it was large. The results of the tests also showed that, on twin-screw ships, the torques and forces on the rudder were practically one-half of those operative when single screws were used, but the ship turning moments were only reduced by about 25 and 15 per cent. for 15 and 30 degrees helm respectively. The relatively smaller loss in turning effect compared with torque on the rudder stock was believed to be due to the presence of the solid deadwood of the twin-screw ship. From tests with the model running astern, it was deduced that, if the torques on the rudder stock when going astern should not exceed those when going ahead, the speed of the ship astern should not be greater than 0·6 of the ahead value.

The results of these experimental investigations at the National Tank are of considerable importance, and the existing knowledge of the effects produced in the manœuvring of ships is being gradually extended as the work proceeds. The next questions which are to be tackled are the actions caused by the variations of prismatic coefficients for both single- and twin-screw vessels and a comparison is to be made of balanced and unbalanced rudders.

AIR DEFENCE.

WHILE the announcement in the House, on Tuesday last, to the effect that the present Government intend to carry on the policy of the previous administration with respect to air expansion and development of the auxiliary force will be received with general satisfaction, some uneasiness is likely to be felt from the tone of the speech of the Under Secretary for Air, Mr. W. Leach, in replying to a motion of Sir Samuel Hoare, who, it will be remembered, was Minister for Air under the late Government. Sir Samuel's motion was to the effect that Great Britain must maintain a Home-Defence Air Force of sufficient strength to give adequate protection against air attack by the strongest air force within striking distance, a policy laid down by the late Government and accepted by the Imperial Conference.

In introducing his motion, Sir Samuel, while assuring the House that he was making no suggestion of possible hostility to our French friends and Allies, pointed out that France possessed 1,000 first-line aeroplanes, about 600 of which were included in the French independent striking force, whereas our home-defence force included only 80 machines. Mr. Leach's reply appears to be mainly a plea for disarmament, although he certainly stated that there

was no change in the policy of the Government, for the time being, with regard to the expansion scheme. It is the use of the phrase "for the time being" which may raise doubts as to the ultimate policy of the Government with respect to air defence, although any change in the scheme which might be contemplated by the Government would, of course, have to receive the approval of the House. It will be remembered that, in July last, the Committee of Imperial Defence recommended that the Home Defence Force should be increased to 52 squadrons, including a total of about 600 machines, which cannot be regarded as an extravagant number, but, at the present time, the whole of the squadrons of the Royal Air Force number about 38, of which 7½ are allocated to Home Defence. This position of affairs should certainly be remedied at the earliest practicable moment, since the maintenance of a one-power standard with respect to air defence is no less necessary than that which is admittedly essential for naval defence.

Mr. Leach also stated that the Government intended to take whatever steps were open to them for the development of civil aviation, and this is all to the good, but it should be pointed out that, as far as the present position and the immediate future are concerned, civil aviation cannot be relied upon to supply a really useful reserve of men and machines for use in time of war. This was amply shown in a lecture by Air-Commodore R. H. Clark-Hall, C.M.G., D.S.O., delivered at the Royal United Service Institution on Wednesday last. The lecturer took as a basis a force requiring 1,000 machines to be kept in service, and for this purpose he estimated 250 pilots and 400 machines would be required each month to make good casualties under war conditions. At the present time, he said, there are only 131 licensed civilian pilots in the country, and about 87 machines engaged on aerial transport. The machines, moreover, included 42 types fitted with 21 different engines, so that they would be of little value to the fighting services, except for such work as bombing, troop carrying, &c. Civil aviation could, however, assist the Air Force in the matter of ground *personnel*, among whom the casualties in war time were less severe than was the case with pilots. Moreover, the development of civil aviaton, by augmenting the aircraft manufacturing resources of the country, would reduce the time which would elapse between the outbreak of war and that at which the industry could meet the full *matériel* requirements of the fighting forces.

The progress of practically all systems for providing increased rapidity of communications, the lecturer concluded, had taken place in three stages viz., experiment, development and expansion. In the development stage, which had now been reached by aerial transport, reliability and economy in working were effected, and when this had been achieved, expansion would doubtless follow rapidly. We have no doubt that civil aviation will eventually expand sufficiently to form a very valuable reserve for the Air Force, in much the same way that the mercantile marine now does for the Royal Navy, and this consideration, in addition to the prospective value of aerial transport from the commercial standpoint, is sufficient to justify the allocation of public funds to assist in its development. It is, however, impossible to predict the probable duration of the development period, which may be protracted even with financial aid from the State, so that for national security in the meantime, there should, we think, be no curtailment of the very moderate programme, referred to above, for the provision of service machines.

THE CRYSTALLINE STRUCTURE OF ORGANIC SUBSTANCES.

ON Thursday, the 14th inst., Sir W. H. Bragg, F.R.S., delivered at the Royal Institution the second of his course of lectures on the above subject.

He commenced by repeating an experiment due to the late Lord Rayleigh, who had shown, many years ago, that it was possible to reflect a "beam" of sound from a series of parallel and equidistant screens of muslin which were suspended from a lazy-tong arrangement, so that the distances between the screen could be readily varied, whilst maintaining their parallelism. When using a very high pitched whistle or a birdcall, giving a note having a wavelength of but one or two inches, quite small screens are effective reflectors, those used in Professor Bragg's demonstration being apparently about 8 in. square. As a detector, a sensitive flame was employed, adjusted so as to respond to these very shrill sounds, which were, in fact, too high to be perceived by the ordinary ear. Professor Bragg showed that the flame responded to the sound, by "ducking," when the spacing between the screens was correctly adjusted, but that with any other spacing there was no response, because the feeble reflections from each of the successive screens were no longer in phase, and so destroyed each other.

This experiment, Professor Bragg said, was precisely analogous to the reflection of X-rays from the

Fig. 5.

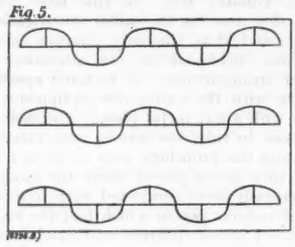


Fig. 6.

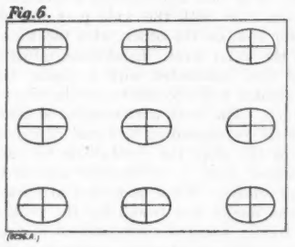
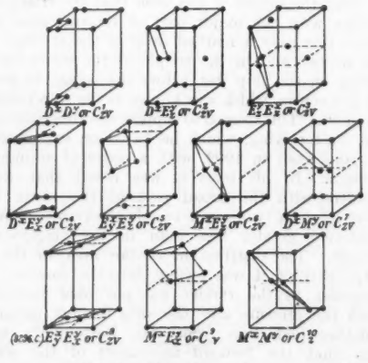


Fig. 7.



planes occupied by the atoms in a crystal. In this case the reflected beam was detected either by photographic methods or by the use of an ionisation chamber. This latter was a metal cylinder filled with air and traversed by a central wire. Between this wire and the walls of the cylinder a high potential difference was maintained, and the wire was connected to an electroscope. When X-rays entered the chamber they ionised the air therein rendering it conductive. The attainment of this state was shown instantly by the motion of the leaves of the electroscope, which were observed under a microscope. The crystal to be examined and the ionisation chambers were mounted on a turn-table fitted with graduated horizontal circles like those of a theodolite. A beam of X-rays being directed on to the crystal, the turn-table was rotated until at some particular point the gold leaves of the electroscope suddenly moved. When this occurred, the reflections between certain of the planes occupied by the atoms or units of the crystal were in phase, and from the observed angle and the known wave length of the X-rays used the distance between these reflecting planes could be determined.

At the outset, Professor Bragg continued, it was thought necessary to use very large crystals, but it was now found better to work with crystals measuring but one or two millimetres across.

In his last lecture he had pointed out that Nature took as her unit of pattern a certain number of molecules, and repeated this at regular intervals, viz., at the intersection of the space lattice. In order to illustrate the elements of crystal structure, Professor Bragg employed three horizontal sheets of glass, equally spaced one above the other. He took as his structural unit, or elemental pattern, wooden ellipses, divided into four parts, which could be displaced relatively to each other, and which were coloured differently top and bottom, so as to represent at need "polar" molecules. The simplest form of cubic crystal was built up, he

Fig. 8.

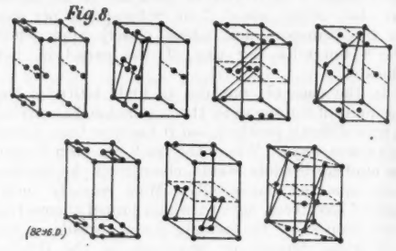
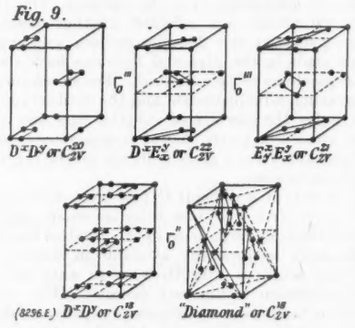


Fig. 9.



said, by placing a complete ellipse at the corners of equal rectangles in the top plate (see Fig. 5), and repeating the pattern on the lowest of the three sheets of glass. The corresponding crystal was of a very uniform type, with right-angles between all its faces and perfect symmetry in the horizontal plane. There might also be symmetry in the vertical plane, but this was not necessarily the case as if the molecules were of the "polar" type, different top and bottom, we should not have symmetry here.

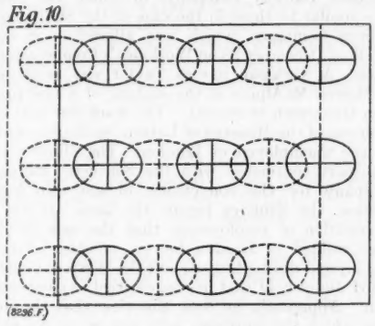
Professor Bragg next shifted the components of his pattern, as indicating in Fig. 6, and showed that there was still perfect symmetry, whilst still later he moved parts of the unit pattern on the top sheet to the sheet at mid-height. In all, he said, 22 arrangements of the constituents of the unit pattern could thus be made, whilst still maintaining the same type of symmetry. The corresponding crystals belonged to the cubic class, and could not be distinguished from each other by their outward form, but only by means of X-ray analysis. The 22 different ways in which this pattern could be arranged were, he said, illustrated by Figs. 7, 8 and 9. The first arrangement shown in Fig. 7 corresponded to the case represented in Fig. 5, and the simpler variants shown in Fig. 7 were obtained by displacing components of the unit pattern into new positions on the faces of the cell. In other cases there was a transfer to the middle of the cell. Each corner of the first of the cells shown in Fig. 7 was supposed to be occupied by the "four-stitch" pattern, but to provide partially for the fact that each unit belonged equally to all the cells which met at these points, these four components were represented as complete only at two of the corners, the others being represented as occupied by two or by one as the case might be. But at each corner there were really four, as already explained. More complicated arrangements were

represented in Figs. 8 and 9, and here special interest attached to the last of the series, which represented the arrangement of the atoms in the diamond.

The object of X-ray analysis, Professor Bragg continued, was to find out where the molecules lay in certain crystals. With cubic crystals the first step was to find out which of the 22 different lattices represented in Figs. 7, 8 and 9 corresponded to particular crystals. The X-rays gave the lattices correctly, but as he had stated in his last lecture, they did not distinguish between polar and non-polar units. The existence of these was, however, generally obvious from the appearance of the crystal.

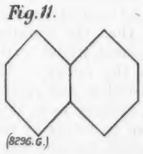
An arrangement corresponding to mono-clinic crystals could, Professor Bragg explained, be obtained by sliding the upper sheet of glass, supporting his models, relatively to that below it as represented in Fig. 10, where the dotted ellipses rest on the lower sheet. These monoclinic crystals were rectangular in the horizontal plane, and had one plane of symmetry. By suitably arranging the pattern, systems could be obtained which had no planes of symmetry. In some of these cases the unit pattern consisted of two elements, both polar, but the poles of the two elements faced in opposite directions. Such crystals had an axis of symmetry, since by suitably choosing this axis the pattern would not be altered by turning the crystal through an angle of 180 degrees. Tartaric acid crystals belonged to this class. This body Pasteur had proved, many years ago, to be a mixture of two varieties of crystal, one of which rotated a beam of polarised light to the left, and the other to the right. From his observations, Pasteur had concluded that the molecules must be arranged in "corkscrew" fashion, and this had been confirmed by X-ray analysis.

Fig. 10.



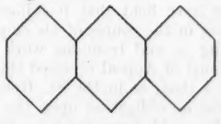
(8296.F)

Fig. 11.



(8296.G.)

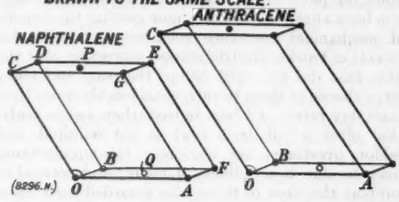
Fig. 12.



It should be noted, Professor Bragg said, that the distance through which the constituents of the unit pattern were shifted was always the half or the whole height of the distance between the faces of the elementary crystal. It was this fact that planes were found separated by half the normal spacing which made it possible to map out the arrangement of the unit pattern in the cells.

Since organic molecules were very complicated it might have been thought better to start on simpler bodies, but owing to the fact that the molecule appeared to keep its shape and character when built up into a crystal, it turned out that certain points were more easily established with these organic crystals than with less complex bodies. If in the molecule the atoms had been piled together at random, the problem would have been insoluble, but the arrangements of the molecules were orderly. Naphthalene, for example, was built up of two benzene rings, as indicated in Fig. 11, there being a carbon atom at each of the 10 corners and a hydrogen atom at eight of these corners. The organic chemist had proved that this was the shape of the molecule in a very wonderful way, and X-ray analysis had now shown that his deductions corresponded to the actual fact, and that this shape was retained in the solid crystal. In anthracene there were similarly three of these benzene rings, as indicated in Fig. 12, and in benzene there was one. A comparison between the three should therefore lead to some important conclusions. Benzene being a liquid at ordinary temperatures, was not a convenient body for X-ray analysis. The X-ray methods had, however, given us the dimensions of the unit cells of napthalene, and of anthracene—with the results indicated in Fig. 13. The crystals belonged to the monoclinic system. It would be seen that both had very similar dimensions in plan, but the anthracene cell was of considerably greater slant height. These heights are given below Fig. 13, in Angström units of 10^{-8} cm. Taking the dimensions given and multiplying the volume thus found by the specific gravity of the material, it appeared that each cell had the weight of exactly two molecules. In Fig. 13 the cells were indicated with a molecule at each corner, and with one at the middle of each of the upper and lower faces. As a matter of fact, however, each molecule at a corner belonged equally to the eight cells which joined each other there, so only one-eighth of the molecule thus situated must be attributed to any particular cell. Hence the eight corners taken together contributed one molecule to the cell. Similarly, the molecule indicated at the centre of the upper and lower faces belonged equally to the adjacent cell. Hence the molecules represented at P and Q contributed each only half a molecule to the cell shown.

Fig. 13 UNIT CELLS OF NAPHTHALENE & ANTHRACENE DRAWN TO THE SAME SCALE.



	OA = a	OB = b	OC = c
Naphthalene	8·34	6·05	8·69
Anthracene	8·7	6·1	11·6

Naphthalene α = BOC = 90°, β = COA = 122° 49', γ = AOB = 90°

Anthracene α = BOC = 90°, β = COA = 124° 24', γ = AOB = 90°

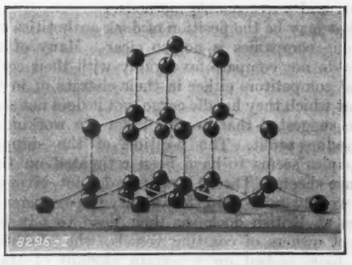


FIG. 14.

It was the additional benzene ring which made the height of the anthracene cell greater than that of the napthalene cell. This ring contained six carbon atoms, and this arrangement of six carbon atoms was found in the diamond, a model of which was represented in Fig. 14. The characteristic feature of the diamond structure was that each carbon atom was at the centre of four other equally distant and symmetrically situated other carbon atoms. This, as the figure showed, gave rise to rings of 6 carbon atoms. The width of this ring had been measured, and if it were assumed that the hexagonal ring in the diamond had the same dimensions as the benzene ring, the excess in the slant height of the anthracene cell over the slant height of the naphthalene cell should be equal to the width of this ring, which had been proved to be 2·5 Angström units. The first observations made (on imperfect crystals) gave, however, a value of about 3 Angström units for this excess in height, as would appear from the figures attached to Fig. 13. Later on, however, Dr. Brady had the good fortune to find a perfect crystal of anthracene, and this gave the length of the slant height OC as 11·18, in place of the 11·6 originally found. The slant height of the naphthalene cell was 8·69 Angström units, so that the difference was almost exactly 2·5 Angström units, which was the width of the hexagonal ring met with in the diamond.

As already mentioned, when the constituents of the pattern out of which the cells were built up were displaced, the displaced particles lay on planes, midway between the principal planes.

Here it would be seen that there were particles at the half distance in plan, but there were none at mid height. Hence it was concluded that there were molecules in the middle of the top and bottom faces of the naphthalene cell as indicated by P and Q, Fig. 13, but not at mid height.

The next step taken was to try and fit into the cell the double ring structure which chemists attributed to naphthalene. It turned out that a very good fit was secured, the molecules being arranged as indicated in Fig. 15, where the large circles were intended to represent carbon atoms and the small ones the hydrogen atoms. At the ends it would be seen that the hydrogen atoms of one cell lay against the hydrogen atoms of the adjacent cell. The bond here was weak, and the crystal cleft along this junction. In the other junctions hydrogen atoms lay against carbon atoms, and the bond was much stronger. The natural faces of the crystal lay along these junctions.

Fig 15.

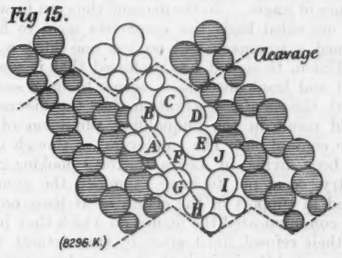


Table Showing Spacing Calculated from a = 8·34, b = 6·05, c = 8·69 (see Fig. 13), *and Corresponding Observations with X-ray Spectrometer.*

Plane.	Calculated Spacing.	Observed Spacing.	Nature of Reflection.
100	7·04	3·46	Strong indication of spacing at 6·92.
010	6·05	2·95	Very weak.
001 (Cleavage)	7·40	7·30	Very strong. Also higher order.
110 (Natural)	4·59	4·55	Strong.
111 (Natural)	4·70	4·63	Moderate.
201 (Natural)	4·17	4·12	Strong.
021	2·79	2·76	Very weak.
101	7·51	3·71	Very weak.
210	3·04	2·99	Strong.
011	3·44	3·39	Strong.

In conclusion, Professor Bragg drew attention to the emptiness of the crystal structure, the distance between the neuclei which reflected the X-rays being very great in comparison with the size of the neuclei, so that the unit pattern, out of which the crystal was composed resembled a piece of lace rather than a continuous solid.

THE DOCKERS' STRIKE AND SETTLEMENT.

AGREEMENT has been reached between the representatives of the employers and employed in the dockers' dispute within a week of the men coming out on strike at the dictation of their leaders. At the time of writing the terms have not been

announced officially, but it seems probable that the men will again follow the advice of their leaders and return to work. That a settlement should have been reached so early in the dispute serves to prove the public contention that if action had been taken earlier on sound lines to investigate dispassionately the facts of the case there need not have been any stoppage. It is true the Government set up a judicial inquiry, but this should have been done, in the interests of the community, before the stoppage. The Court of Inquiry had only a forenoon meeting, and although it may have shown the way to a proper treatment of the dispute, it did not directly bring about the agreement. The terms are not material so far as the public are concerned; but the lessons to be derived from the procedure of the negotiations which failed to prevent a strike ought again to be enforced.

It is much to be deplored that from the outset both union and employers adhered to the obsolete and discredited practices of the strike mechanism. Though the actual facts by which the merits of its demand must be decided were then known only to the employers, the Union seems to have made no attempt to ascertain them, but presented its claim on the strength of figures collected *ex parte*, and with no apparent desire for more relevant information except in so far as it might justify an advance of wages. To the demand thus put forward on a one-sided basis the employers seem to have returned a summary and no less one-sided reply. The Union, though it has professed that it sought a full and frank discussion, seems to have sought it with the mental reservation that the discussion should result in the unqualified admission of its entire contention. The employers, as though they had been living in Lewis Carroll's looking-glass country, seem not to have examined the grounds alleged in support of the claim, or at least not to have communicated the figures on which they justified their refusal, until after, by that refusal, they had accepted the Union's challenge and precipitated the strike. Both parties, in fact, proceeded on the time-dishonoured lines of seeking to adjust an industrial dispute by methods of haggle and somewhat clumsy negotiation. No attempt appears to have been made to consider the matter as one in which the ultimate interests of each side could be furthered only by arriving at the truth, and not by scoring a victory through mere negotiation or obstinate force. On the contrary, the energies of each party were devoted to endeavouring to screw concessions out of the other, and not, as the circumstances of modern industry demand, to ascertaining what the other side was really able to concede.

In any industry the ability of employers to pay wages or advances is obviously limited by what it earns, and in any industry that is subject to international competition advances that increase the cost to the consumer may drive the business abroad, and stop not only the advance but the wages themselves. Accordingly, methods of merely tactical negotiation supplemented by force entail the risk of actually reducing the employment that the industry can offer, and when they appear to be most successful may be bringing wholesale calamity on the industry. An instance notorious in recent years is the building trade, in which the success of trade union and other influences in reducing the amount of work done for a given cost has lessened the amount of employment disastrously, both to the industry and to the community it serves. This instance illustrates how to a greater or less extent the community is interested in any possible interruption of industry, and the service of the docks is an example of an industry in which it is interested vitally. A dock strike begins, like any other strike, by coercing workers who, by the exceptional position for the time being of the dominant minority in the trade union, have little practical option but to obey the orders of the minority, though they may themselves be indifferent or even opposed to a strike. The next class to suffer is the shipping industry, though in the last resort it can take itself and some part of its business to other ports; but with the suspension of its activity in home ports the whole import and export trade of the country is hung up, and its prospects are jeopardised, with obvious results to the employment in the industries affected. With the suspension of deliveries from dock warehouses the entire body of individuals that constitutes the community is exposed to necessary increase of prices, and ultimately to privation. The situation prior to a strike in the docks may be discussed between employers and men, who are directly concerned; but such a discussion leaves out of account the fact that the general population and the trade of the country constitute a third party, which in the aggregate is no less interested in the dock service than the parties whose discussion determines its fate.

The merits of the dock-workers' claim was in no way prejudged when it was contended that nothing in their present situation warranted them in flouting communal interests by launching an avoidable strike. Before the war dock workers earned 7*d.* an hour; to-day they earn 1*s.* 3*d.* an hour on the rate against which the strike has been called, and could have had 1*s.* 4½*d.* an hour on the terms that the employers offered. This is now agreed to between the representatives of both parties, with the promise of another 1*s.* per week early in June. The settlement further requires inquiry into the very difficult question of decasualisation.

Even this improvement in the dockers' position falls short of the actual advantage they have gained in the last few years. A large part of their work is done on piece-work; and though the rates have not been changed, they are now getting the benefit of mechanical assistance such as electric trucks, elevating trucks, electric cranes, conveyors and the like, that did not exist before the war, and allow large classes of them to earn considerably more than their day rates. Of late, indeed, they assert, truly, that often a full day's work is not required, and seldom overtime; but, obviously, this circumstance may be due to a dullness of trade, and seemed to support the view of those who regarded their claim as inadmissible. These are merely prima-facie considerations, the real value of which can be determined only by the necessary inquiry. They are, however, sufficient to show that dock workers after the war are in a position sufficiently better than they occupied before the war to disallow a claim on their behalf to the redress of alleged grievances by violent and unreasonable methods.

What may be the position of dock authorities and shipping companies is not so clear. Many of the docks do not compare favourably with their continental competitors either in their charges or in the rate at which they handle cargo, yet it does not seem to be suggested that any of them are working at an undue profit. The position of the shipping companies seems to have been estimated on their balance sheets. These, however, do not give any trustworthy guide as to their ability to pay increased wages at British docks or their need to pay less. Except owners of coasting vessels, who doubtless may have picked up a certain amount of traffic during the railway strike and whose accounts must therefore be somewhat abnormal, all owners must use foreign as well as British ports, and more detailed accounts than balance sheets give would have to be examined in order to disclose where the profit has been earned. Many, moreover, of the largest owners have considerable passenger trade, on which the incidence of dock labour is relatively small, and an examination of their cargo accounts would be necessary to show what resources they really earn for facing an increase of their dock expenditure.

The Court of Inquiry would doubtless have obtained and considered such information, but not any more completely than a conference of the employers and the union could have obtained and considered it, had both of them been disposed to do so. The much graver difficulty of decasualising the industry is not likely to be easily settled by any formal or controversial investigation. At present the docks are the last resort of men who are unskilled and out of work, and their needs will not be satisfied merely by giving a squatter's title to a limited number of men to exclude or take precedence of others. The difficulty, moreover, lies not only in the extent and the fluctuations in the supply of dock labour, but also in what seem to be the necessary daily fluctuations in the demand. What is required, in fact, is to find a mechanism for giving continuous employment to fluctuating bodies of workers on discontinuous and casual work. To do so completely is plainly impossible, and to choose wisely the means that will do the most to the desired end will call for a deliberate and cordial consultation between the two parties most directly concerned. This can hardly be expected if the country's trade lies imprisoned as a hostage to disputants incapable of studying each others case, or under the threat that it will be so if an agreement is not reached.

Among some of the dock workers who are suffering by the strike, it is now being said that their interests are being exploited in order to make and maintain the reputation of their leaders. No one wishes to believe this; but the truth of the impression must be tested by the readiness with which the leaders on each side desist from playing at being lawyers, and co-operate in finding a practicable and just solution of the problem of casual dock labour.

NOTES.

Workmen's Compensation.

The Court of Appeal disposed, last week, of a case Taylor *v.* Sir Robert McAlpine and Sons and The Southern Railway Company, in which the facts were similar to those in the case of the St. Helen's Colliery Company, which was alluded to in our article of December 28 on Workmen's Compensation Cases. A workman named Taylor was employed by Messrs. McAlpine in the making of a new road from Greenwich to Strood. The work was part of a scheme of the Ministry of Labour for finding work for the unemployed of London. The Ministry of Transport contracted with the Southern Railway Company for the conveyance of the men from London, the Ministry paying the fares. It was a a condition of employment that the men should have resided in London for six months. Taylor was injured during transit, and the Western County Court Judge held that he was entitled to compensation. Apparently he took the view that the free pass which the workman held was to be regarded as part of his remuneration, and he seemed somehow to have held that it followed that the workman was in the course of his employment whilst travelling to and from his work on the railway. The Court of Appeal reversed this decision, and pointed out that, as in the St. Helens Colliery case, there was no obligation upon the man to travel by rail. He could have gone to his work by any other convenient means of transit. Further, the men were engaged from day to day, and their employment did not begin until they reached Strood: when a man left work one day there was no obligation on him to go back on the next—or any other day—and no obligation on Messrs. McAlpine to employ him if he did go back. Accordingly, the accident did not arise in the course of the employment, and the injured man was not entitled to compensation under the Workmen's Compensation Acts.

British Shipping.

The most efficient instrument of transport is still British shipping whether the basis of comparison be the volume of goods carried or their value. From the Annual Report for 1923–1924 of the Chamber of Shipping of the United Kingdom, we learn that the registered gross tonnage flying the British Ensign was 18,875,000 at the beginning of the European War, and that, in spite of the losses suffered during the hostilities, a net increase of 200,000 tons is shown to-day, while the figures for the British Dominions have increased by 812,000 tons. This total increase of just over one million tons is small in comparison with the contributions of some other nations to the total increase of 15½ million tons. The share of the growth accredited to the United States amounts to 10¼ million tons, while the figures for Japan, Italy, France and Holland all show a greater improvement than those of the British Empire. Although it is true that the United Kingdom has reduced its share of the world's tonnage from 44 per cent. to just under 33 per cent., a much greater proportion of the ships of other nations are obsolete or otherwise

uneconomic, and larger percentages of their mercantile fleets are laid up. On a conservative estimate, 6 million tons of foreign shipping are unemployed, of which the United States holds at least 4 million tons. Great Britain, in contrast with this, has only 750,000 tons of her shipping idle, notwithstanding that there is no assistance from subsidies or protection provided against unrestricted competition by flag discrimination. Approximately one-half of the vessels of the British mercantile marine are less than ten years old, which does not compare unfavourably with the figures for the whole world, despite the heavy construction of ships in some countries in war time. The economic conditions of British shipping, however, causes considerable anxiety. Operating charges are still high, and the wages bill is one of the heaviest component items. The upset state of currencies on the Continent is also a cause of unequal conditions of competition, the German wage rates for seamen being about one-third of those of British ships, and in vessels of almost every foreign country the rates are lower than for Great Britain. The position regarding freights may be judged from the index figures. Taking the year 1920 as represented by 100, the Chamber of Shipping index figure for January, 1921, was 46·31, but it fell to 32·97 in January, 1922, and to 29·42 twelve months later. During 1923 the low level of 25·03 was reached in August, but there was a subsequent recovery, and at the year end the value was 28·06. The world is doing much less trade, and the irresistible law of supply and demand had caused great changes. Passenger traffic had fared much better than general cargo-carrying, which has, indeed, been conducted at a serious loss.

The Reliability of Marine Oil Engines.

An essential requirement in any type of marine engine is absolute reliability, since on it depends the safety of the ship at sea. Little need be said nowadays about the high standard attained in this respect with the marine steam engine, for it was generally appreciated that the exceptional reputation of British engine-builders has been founded on the sturdy constructions they have adopted to meet the most exacting requirements that have confronted them. The motor ship is a comparatively recent innovation, and, though it has attained a great measure of success, it must not, at any time, be forgotten that only by the production of engines which can be relied upon for consistent and continuous running on full load can general satisfaction and extended application be achieved. Many shipowners are studying the question of reliability of the marine oil engine very closely, and for this reason the detailing of experiences at the present time is of great value. Mr. W. J. Still has recognised this, and in the paper on "The Type of Still Engine required for Marine Service," which he read on Friday last to the North-East Coast Institution of Engineers and Shipbuilders, he showed the advantages accruing from the outstanding features of the design of the Scott-Still engine. When waste heat was utilised in the manner adopted in this engine the heat stresses in the material structure were reduced to a very low value, because there was only a small difference of temperature between the gases and the cylinder walls. Actually, though the engine has the characteristic high power output for a given cylinder volume of the other two-stroke cycle engines, the heat flow was comparable with that of the four-stroke engine. Thin walls were employed, and to withstand the pressure stresses due to combustion the liners were ribbed in such a way that they did not take the stresses, but transmitted them through to the steel hoop by means of ribs which became piers supporting a girder. Though not solely essential to the Still engine, this construction was adopted because safety was considered of more importance than first cost. Overload may be carried by a Still engine by the use of the extra steam generated in the waste heat boilers by the use of oil burners and in that way full load could be maintained, even though the combustion end of one cylinder was out of action. The significance of fuel injection and other factors in reliable running, such as water circulation, lubrication and the design of bearings were reviewed by the author, who claimed that in the Scott-Still engine the substitution of steam for the compressed air of the common Diesel engine made for simplicity, safety and economy.

The New Regulations for the Grinding of Metals and the Cleaning of Castings.

In June of last year the Home Office published, through the Stationery Office, a Report on the Grinding of Metals and Cleaning of Castings, with special reference to the effects of dust inhalation upon the workers, by Mr. E. L. Macklin, H.M. Engineering Inspector of Factories, and Dr. E. L. Middleton, H.M. Medical Inspector of Factories. The Report contained the results of a prolonged investigation which had been made by these gentlemen with the main object of ascertaining the conditions under which the grinding of metals and the cleaning of castings were done, and the risks to health involved in the work, with special reference to danger from dust. Among the conclusions to which the Reporters came were the following: That dust is generated in varying degrees in all processes of grinding and glazing of metals, and the somewhat prevalent belief that dust is not generated in wet grinding as ordinarily carried on is erroneous; that the amount of dust evolved at dry grinding on grindstones, manufactured wheels and glazing appliances can in most cases be satisfactorily removed by the application of suitably designed dust exhaust plant; that the dust evolved at grinding and wet manufactured wheels is much less in amount than that evolved at dry grinding; that a considerable proportion of dust from the process of racing can be removed by suitably designed dust exhaust plant; that the usual method of keeping a grindstone wet by running it in contact with water in a trough is harmful, because the water becomes increasingly dirty and the swarf thrown off by the grindstone becomes increasingly charged with sandstone particles; that it should be possible to grind with a fresh supply of water laid on at the top of the grindstone, drainage being provided at the bottom of the trough; that frequent renewals of the air of the grinding room by means of extraction fans and fresh air inlets would greatly remove the dust content of the atmosphere of the room; that the structural conditions in many cases are prejudicial to health and safety, and need overhauling; that persons employed at grinding on wet grindstones should be given facilities for washing and for storage of food and clothing; that grinding and incidental processes on grindstones should be effectively separated from all other processes, and that the substitution of manufactured wheels for grindstones is of paramount importance. The Report contained two suggested sets of regulations, one to deal chiefly with the cutlery trade and the other to deal chiefly with the general grinding of metals and the cleaning of castings. Since the Report was issued the Factory Department have apparently revised the suggested regulations, and they have now been formally issued in a revised form by the Home Office in terms of the Factory and Workshop Act, 1901. The object aimed at by the Factory Department, viz., the safeguarding of the health of the workers, merits every sympathy, but there will probably be much difference of opinion as to whether the proposed regulations are practicable. Parties interested have forty days from February 8 within which to lodge objections to the draft regulations, with the Secretary of State.

The Economics of Engineering.

The term economics, as Count Smorltork would say, "surprises within himself" a study of no inconsiderable magnitude. Moreover, there is no subject on which professional expositors differ more widely in their conclusions, nor in which, *a priori*, logical deductions from first principles are more systematically falsified by the actual course of events. In view of the bewildering conflict between the views of opposing schools, it is not surprising that the decision of the Council of the Institution of Mechanical Engineers to include "The Economics of Engineering" in the syllabus of its examinations for the associate membership has seriously perturbed certain prospective candidates. It was well, therefore, that, with the approval of the Council, Admiral Sir George Goodwin devoted the major part of the address delivered on February 12, before the King's College Engineering Society, to allaying these apprehensions and to explaining the limited nature of the attainment demanded. As is practically always the case, the syllabus is a very inadequate guide to the actual requirements, and since the new regulation does not become effective till October next, no old examination papers are available to supplement this syllabus. It cannot be denied that many very able engineers have little business knowledge. In part this is due to the absorbing and interesting nature of their own special work. It was, in fact, on some such ground that Captain Jones declined the partnership offered him by Andrew Carnegie, and more recently the head of a large and important firm retired because his very success, and the consequent growth of the undertaking, demanded that he should concentrate the whole of his attention on matters of business and administration, whilst his real interests lay on the technical side. Whilst quite intelligible, this mental attitude has some distinctly unfortunate consequences, as it tends to concentrate the control of industry in the hands of those with clerical or statistical tastes, a condition which already rules in most government and municipal undertakings. It was quite in accord with this long-established precedent that when it was decided to give government aid to the dye industry, the chairmanship of the undertaking was conferred on a lawyer, whilst scientific and technical advisers were of set purpose excluded from the directorate. Such a condition of affairs is not in the interests of the community, but in part at least, the remedy lies with the engineers themselves. They must make up their minds to acquire at least the elements of the non-controversial parts of economics; to learn something as to how commerce is conducted, to understand a balance sheet, to grasp the true significance of the technical terms used, and to realise the part played by banks, and the nature of trading documents generally. This, Sir George Goodwin was able to assure his hearers will pretty well cover the new requirements for the associate membership, so far at least as "external" economics is concerned. There are other matters relating to the layout of works and management generally in which the engineer would in any case have to interest himself, even if he left purely business matters to others.

The Staffordshire Iron and Steel Institute.—We have now received volume xxxviii of the proceedings of this institute for the session 1922-1923. It contains interesting papers with the discussion therein dealing with ingot segregation, arc welding, repeated stress testing and its results, and native methods of making iron in India.

The Combustion of Coke.—Some coke chemists have recently spoken of a combustibility of coke, by which they mean the power of the incandescent coke to reduce carbon dioxide, as distinct from the general combustion. Since the combustion of coke depends upon the equilibrium between carbon, oxygen, carbon monoxide and carbon dioxide, and since this equilibrium reaction changes with temperature, pressure, surface development and other conditions, there is not much gained by this distinction, nor by the term reactivity of coke generally used, and which Dr. H. Bähr prefers to combustibility. Bähr, of the works of Otto and Co., Dahlhausen, on the Ruhr found that the reactivity was not affected, or only very slightly, by the volatile constituents and the porosity of the coke, though these factors influenced the ignition temperature. Impregnation of the coke with salts of alkalis magnesium and aluminium had no influence either; but impregnation with iron salts increased the reactivity, which decreased again when the iron salts were extracted by means of acid. This catalytic influence of iron on the combustion of coal and coke is not surprising; it has been recognised for some time that even the small amount of mineral constituents very finely disseminated through coal affects the combustion more than one would expect from the proportion of the mineral constituents, which are, therefore, said to act as catalysts. Bähr does not suggest that coke might be improved by soaking it in solutions of iron salts; the necessary redrying of the coke would make any advantage gained illusory. But his lecture led to an animated discussion reported in *Stahl und Eisen*, from which we may conclude that coke combustion requires much further investigation. One of the speakers mentioned that he had apparently improved his coke by mixing it with dust from the throat of a blast furnace, but combustion had become irregular.

INDUSTRIAL NOTES.

Since our note on page 216 of our last issue, the port employers, in the course of a conference last Friday at the Ministry of Labour, confirmed their offer to concede in the national interest 1*s.* of the men's demand, to take effect on March 3, and to restore piecework rates current in June, 1923, where applicable. They regretted they were unable to meet the men's demand for a further shilling, but they were willing, prompted again by consideration of the national interest, to refer this part of the claim to immediate arbitration. On the question of maintenance, they offered at once to enter a joint conference with the whole-hearted endeavour to find a solution of this difficult and complicated problem. The men rejected these offers, and came out on strike at all ports on Saturday, the 16th inst., at noon. On Monday last, the Ministry of Labour appointed a court of inquiry, under Part II of the Industrial Courts Act, 1919, to inquire into the causes and circumstances of the present dispute and to report thereon. Mr. Shaw, Minister of Labour, directed the following to constitute the Court: Mr. Holman Gregory, K.C., chairman; Mr. H. Boothman, J.P.; Sir Andrew Duncan. The Secretary to the Court is Mr. G. H. Ince, Ministry of Labour. The strike was settled at 2 a.m. yesterday, following a conference of employers' representatives and men's leaders at the Ministry of Labour. At the time of going to press it is announced that the employers offered that 1*s.* increase should be granted immediately and another shilling early in June with the condition that there be an inquiry into the questions of maintenance and decasualisation. We shall report further on the proceedings in our next issue; we deal with the strike in an article on page 245 of the present one.

The secretary of the London Iron and Steel Exchange, Limited, states that the strike at the docks has disorganised the iron and steel trades, although the full effect of the stoppage has not yet been felt. European and import business has practically ceased, and under those circumstances the tone at the weekly meeting of the exchange, last Tuesday, was subdued. It was perhaps fortunate that most of the orders on the British manufacturers' books were for home users, but even so there were sufficient orders for export on hand to cause serious accumulation of material at the docks if the dispute were prolonged. The merchant trade of the country will be badly affected by the dispute, as delays in deliveries are inevitable, and this invariably leads to attempted cancellations by overseas buyers. There was a chance that the British steel makers would benefit from congestion on the Belgian railways, and at the port of Antwerp, by the diversion to them of orders usually placed abroad, but the strike has prevented this business from developing. The overseas enquiry, which assumed large proportions, last week, has died down again, and is not likely to revive until the labour position becomes clearer. The dock strike having been settled as above stated, we hope the iron and steel trade will soon regain full activity. Considerable irritation, the secretary adds, is felt at the placing of another South African contract for railway material with Krupps, although the quantities involved are not large.

The ninety-seventh quarterly report, to December 31, 1923, now issued by the General Federation of Trade Unions, states that very few disputes during the quarter have financially affected the funds of the Federation, and the reserves have benefited, the excess of income over expenditure for the quarter being just over 12,140*l.*

The Ministry of Labour state that during the first three weeks of January there was a continuous improvement in employment. In the fourth week, however, the effects of the railway dispute caused temporary stoppages of work at many of the coal mines, and at a considerable number of factories in industries using large quantities of coal or dependent on the railways for transport facilities. Among workpeople insured under the Unemployment Insurance Acts in Great Britain and Northern Ireland the percentage unemployed on January 28 (the last full day of the railway stoppage) was 11·9, compared with 10·7 on December 21, 1923, and with 11·5 on November 26, 1923. On January 22, 1923, the corresponding percentage was 13·1. Among members of Trade Unions from which returns were received the percentage unemployed was 8·9 at the end of January, 1924, compared with 9·7 at the end of December, 1923. The total number of workpeople on the live registers of the Employment Exchanges on January 21, 1924, in Great Britain and Northern Ireland, was approximately 1,253,000, of whom 925,000 were men and 248,000 were women, the remainder being boys and girls. On December 31, 1923, the total was 1,289,000, of whom 954,000 were men and 264,000 were women. On January 28 the total had risen to 1,322,000, but there was a marked improvement after the settlement of the railway dispute, and by February 4 it had fallen to 1,248,000.

In the industries for which statistics are available the changes in rates of wages reported as having taken effect in January resulted in an aggregate increase of 88,000*l.* in the weekly full-time wages of nearly 1,000,000 workpeople, and in a decrease of 25,000*l.* in the weekly wages of over 480,000 workpeople. Among the principal groups of workpeople who obtained increases in wages were coal miners in Yorkshire and the East Midlands, the Forest of Dean, and Scotland, whose wages were raised by amounts ranging from about 1½ to 5½ per cent. on current rates. In the railway service there was an increase of 1*s.* per week in the wages of many of the principal grades, under the operation of the cost-of-living sliding scale. Men employed in the gas industry received an increase of ½*d.* per hour, or 4*d.* per shift, and there was an increase of ½*d.* per hour in the wages of men employed in the waterworks and electricity supply industries in many districts. Other groups of workpeople whose wages were increased included those employed in the textile bleaching, printing, dyeing, &c., trades and in the seed crushing and oil milling industries, electric cable makers, tube makers in Scotland, bobbin and shuttle makers, cement makers, coal tippers at the principal ports, coal porters in London, and warehouse workers at Manchester. The principal reductions in rates of wages affected coal miners in Northumberland, Durham, and South Wales and Monmouthshire, the amount of decrease varying from under 1 to about 5½ per cent. on current rates, and blastfurnace workers in most districts in England and Wales, whose wages were reduced by amounts ranging from under 2 per cent. on current rates in Cumberland and North Staffordshire to over 7½ per cent. in Cleveland. Under the Trade Boards Acts there were increases in the minimum rates fixed for certain classes of workpeople.

On February 1 the average level of retail prices of the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel, light and miscellaneous items) was approximately 79 per cent. above that of July, 1914, as compared with 77 per cent. a month ago and a year ago.

The number of trade disputes involving stoppages of work, reported to the Labour Department as beginning in January, was 37. In addition, 11 disputes which began before January were still in progress at the beginning of the month. The total number of workpeople involved in all disputes in January was approximately 83,000, as compared with 10,000 in the previous month, and 19,000 in January, 1923. The estimated aggregate duration of all disputes during January was about 629,000 working days, as compared with 83,000 days in December, 1923, and 117,000 days in January, 1923. The principal dispute was that involving railway enginemen, which was in progress from January 21 to 29.

The report for January issued by the United Patternmakers' Association states that unemployment in the trade is steadily decreasing, although the figure of 11 per cent. unemployed among the members is still double the average of the society. In viewing the situation, consideration should be given, adds the report, to the number of members who have gone abroad, or who have left the trade. The last quarterly balance sheet to December, 1923, shows an excess of income over expenditure of approximately 1,540*l.* For the year it is estimated that the excess figure will be about 12,000*l.*

In the report for the present month of the United Society of Boilermakers and Iron and Steel Shipbuilders, the secretary states that "wages are at the lowest point and steel and other materials are also at the lowest price with the probability of higher prices in the near future." No date being given for establishing a comparison, this statement is quite incomplete and unsatisfactory. In the matter of steel ship plates the price immediately before the outbreak of war approximated 6*l.* 10*s.* per ton. On January 1, 1923, steel ship plates cost 9*l.* 10*s.*, the price being 10*l.* 5*s.* in December last. Steel boiler plates, sections, rails, &c., also show heavy increases in cost, not only compared with pre-war quotations, but also with those ruling a year ago.

In the same report, the secretary of the Boilermakers' Society complains of British journals which, he says, "are still telling us of work going abroad"; he then quotes from a Dutch newspaper, according to which "it is probable that still more orders will go to Britain, for the British shipbuilders' tenders are 10*s.* a ton less than the Dutch. . . ." As against this statement and quotation, we find in *The Manchester Guardian* for the 15th inst. the following: ". . . It has to be admitted that the economic condition of the British shipbuilding industry is bad. If wages are low, profits are stated to be still lower; indeed, many of the British shipyards are reported to be working without any profit in order to find some employment for their workers. The percentage of unemployment is about the highest of any of the principal industries. Continental competition is keen, a newcomer in the industry being France. In a recent competition for a new Dutch liner a French firm secured the order against Dutch shipbuilders, who have a 30 per cent. wage subsidy from their government, and against British firms, who neither have, nor wish to have, any subsidy. . . ." This question may evidently be made to bear different complexions, depending on what individual cases are considered.

A meeting took place in London last Saturday between representatives of the Shipbuilding Employers' Federation and of the Federation of Engineering and Shipbuilding Trades, with a view to give preliminary consideration to the claim formulated by the latter body for a 10*s.* per week increase in wages for all grades of shipyard workers, referred to in our last issue. The meeting adjourned after the men's side had outlined their case. Further conferences are to be held to deal with the claim. Southampton shipyard engineers are demanding a wage increase of 17*s.* 6*d.* per week.

An announcement has been made to the effect that the members of the Amalgamated Engineering Union have been requested by their leaders to take a ballot on a proposal for a 3*d.* levy, to meet an appeal which comes from the International Metal Workers' Federation on behalf of the German Metal Workers' Union. It is stated that the German metal workers contributed about 20,000*l.* to assist the Amalgamated Society of Engineers during the lock-out of 1897-98, and that during the lock-out of 1922, the International Metal Workers' Federation contributed a sum exceeding 52,000 Swiss francs. Besides the Amalgamated Engineering Union at least eight other British unions form part of the International Metal Workers' Federation, and the members of these other unions may also be requested to take part in the contribution. It is not impossible that the German grants above referred to were made, with an ulterior motive, since the custom of Germany has always been to fish in troubled waters. After the Franco-German War of 1870, German socialists fraternised with French socialists, but told them that in case of war between the two countries they would fight their French "brothers" tooth and nail. They would fight their British "brothers" with no less energy.

Members of the Amalgamated Engineering Union employed at works in Sheffield and district are agitating for an increase in wage. The wage now paid to skilled engineers is 2*l.* 19*s.* 6*d.* per week, a figure which, they claim, is entirely inadequate. A local sub-committee of the Amalgamated Engineering Union has been formed in Sheffield to take the matter up and report to the Executive Council. The increase demanded is, it is announced, 15*s.* 6*d.* per week.

Volta Electric Furnaces.—A report in *Iron and Steel of Canada* is to the effect that the Volta Manufacturing Company, Limited, Welland, Ontario, have contracted for the following electric steel furnaces during the month of December: One 1-ton Héroult electric steel furnace for the Welland Steel Castings, Limited, a new company; and one 6-ton Héroult furnace for the Imperial Japanese Navy, the latter contract having been placed through the New York office of the Japanese Navy. A few months ago the company supplied the Buffalo Bronze Die Cast Corporation, Buffalo, N.Y., with one of their latest type three-phase electric brass furnaces. This furnace has a rated capacity of 3 to 4 tons per heat; it is now being operated on a 24-hour day basis and is melting an average of 41 heats per day with a current consumption of less than 240 kw.-hour per ton of metal melted.

Malleable Iron Castings for Motor Cars.—A publication numbered 5,022–1923, and recently issued by the British Engineering Standards Association, contains the British standard specifications for malleable-iron castings for motor cars. The specifications cover two grades of material, viz., European and blackheart malleable iron, and impose limits in the chemical constituents of both grades. The chemical composition of the castings, however, is regarded as a less useful criterion as to their suitability for any particular service than are mechanical tests, and consequently the chemical limits have been made as wide as possible. Tensile and bending tests are fully specified, both as to dimensions of test bars and results required. Copies of the specification can be obtained from the Publications Department of the Association, 28, Victoria Street, Westminster, S.W. 1, price 1*s.* net or 1*s.* 2*d.* post free.

THE MEASUREMENT OF AIR FLOW.

By R. O. KING, Officer-in-Charge, Engine Section, Air Ministry Laboratory.

(*Concluded from page* 137.)

The Callendar Hot Wire Anemometer. (Volt Thermometer Method.)—The Callendar method of hot wire anemometry consists in combining the constant resistance method with the device called by him a volt thermometer, and developed some years ago for a recording wattmeter. The volt thermometer (see Fig. 3), is placed in series with the bridge, one arm of which is the anemometer wire. The ratio coils of the bridge are made of high resistance compared with the anemometer wire and the resistance it is balanced against. If the ratio coils are 400 ohms and 100 ohms, the anemometer wire 4 ohms when heated, and the standard resistance 1 ohm, then an error considering heating effect (C^2) of only 1 part in 10,000 is involved in assuming that the current through the volt thermometer is the same as the current through the anemometer wire. Instead of measuring volts across the anemometer wire, the reading is taken across the terminals of the volt thermometer. It is a characteristic of the volt thermometer that this voltage is approximately proportional to C^2. Now C being taken the same for both anemometer wire and volt thermometer, the equation connecting heat loss from the anemometer wire and air velocity

$$\text{Watts } (C^2R) = B\,U^{\frac{1}{2}} + D$$

becomes V (volts) $= k\,U^{\frac{1}{2}} + D$, since resistance R is constant for the method, and at higher velocities neglecting D,

$$U = k\,V^2$$

and the quantity U being measured varies only according to the square of the quantity observed instead of the fourth power as for the constant resistance method when volts across the hot wire itself are observed.

From the equation $U = k\,V^2$ as before

$$\frac{dU}{U} = 2\,\frac{dV}{V}$$

or U changes twice as fast as V, and 1 per cent. change in V corresponds to 2 per cent. change in U. The accuracy attainable is then the same as for the constant resistance method using a wattmeter, as would be expected. In practice the accuracy is somewhat better because with the volt thermometer as arranged, the volt reading increases somewhat faster than the square of the current. The volts increase in the ratio 5 : 1, when the current is increased in the ratio 2 : 1

The volt thermometer besides giving a somewhat greater accuracy has the additional advantage over a wattmeter in that it affords a simple means of greatly extending the range of the anemometer, still using a single voltmeter as the indicating instrument. This extension of the range is obtained by using a volt thermometer of several fine wires in parallel, arranged so that one or more of the wires may be put in circuit as desired.

The Function of the Callendar Volt Thermometer as Applied to Anemometry.—Consider first a fine wire heated by an electric current, this wire being such that its resistance does not change with temperature. The volts across its terminals will then always be directly proportional to the current flowing through it, regardless of its temperature, *i.e.*, $V = c\,R$. If now a wire be used having a considerable change of resistance with change of temperature, the resistance will increase with rise of temperature due to the heating effect of the current, and the volts across its terminals will be $C\,R + C \times$ increase of R, the current being the same as in the first case.

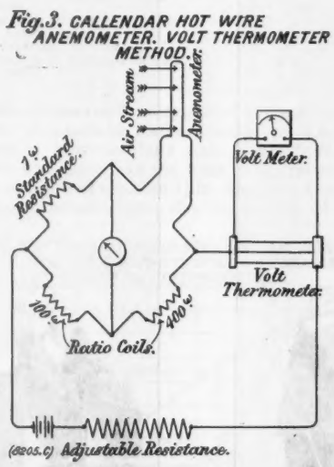


Fig. 3. CALLENDAR HOT WIRE ANEMOMETER. VOLT THERMOMETER METHOD.

Callendar has shown experimentally that over a considerable range there is a linear relation between volts and resistance, thus $R = a\,V + b$.

For a 3-in. length of 0·004 in. diameter platinum wire $R = 0{\cdot}607\,V + 1$ ohms approximately. But $V = C\,R$, where C is the current through the volt thermometer and the anemometer in series with it, hence C (anemometer current) $= V/R = V/0{\cdot}607\,V + 1$. Such a wire will easily stand a current giving 5 volts across its terminals, and the volt reading increases faster than the square of the current 1 to 5 for volts for 1 to 2 for C. Remembering that the velocity of air flow over the anemometer wire is approximately proportional to fourth power of the current through it, it follows that the volts read on the volt thermometer bear some relation to the velocity of air over the anemometer between a linear and a second power one. Thus a scale more favourable for accuracy than a wattmeter scale or the scale of a special ammeter reading C^2, is obtained.

If two similar volt thermometer wires are used in parallel, then

$$C = 2\,V/(0{\cdot}607\,V + 1)$$

that is the current range that will give 5 volts reading (150 scale divisions) on the voltmeter is extended in direct proportion to the number of volt thermometer wires used in parallel. Thus with four ranges, given by 1 to 4, volt thermometer wires in parallel of the above dimensions, the current range corresponding to 1 volt to 5 volts on the terminals is extended from 0·62 ampere to nearly 5 amperes. The percentage accuracy is the same for each of the four ranges, and is five to ten times that which could be obtained with a single ammeter having a uniform scale from 0 ampere to 5 amperes, when applied to a hot wire anemometer. Also owing to the overlap of the ranges it becomes unnecessary to use the low readings giving poor percentage accuracy, and if the voltmeter readings can be relied on to one-quarter of a scale division, the accuracy attainable will usually be better than ½ of 1 per cent. for any velocity up to 300 ft. per second, corresponding to a mass flow of 1,000 grammes per second in a 4 in. diameter pipe.

The application of the volt thermometer to hot wire anemometry thus enables accurate measurement of air velocity to be made over a very extended range and with a very satisfactory degree of accuracy, using only a single 5-range voltmeter as the indicating instrument. The only other instruments required are a galvanometer for use in keeping the bridge in balance and an adjustable rheostat for regulating the heating current.

Arrangement of Callendar Hot Wire Anemometer for Practical Use in Air Measurement.—Referring to Fig. 3 it will be seen that the ratio coils, the standard resistance and the volt thermometer are all parts on which no adjustments are required after completion, so for convenience in use they can be assembled into a single box. Such an arrangement is shown in Fig. 4. The box, made of sheet brass, is provided with terminals for connecting leads to the anemometer wire, the voltmeter, the galvanometer and the battery circuit including the rheostat for adjusting the heating current. The view shows the complete apparatus with all connections arranged for measuring the rate of air flow in a 2-in. diameter tube.

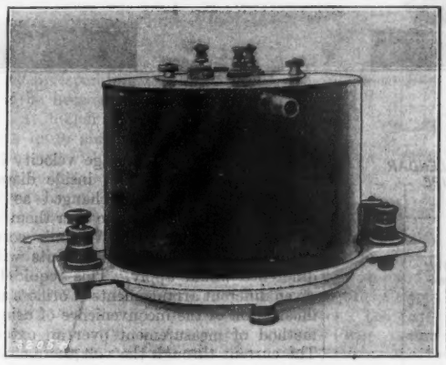


FIG. 4.

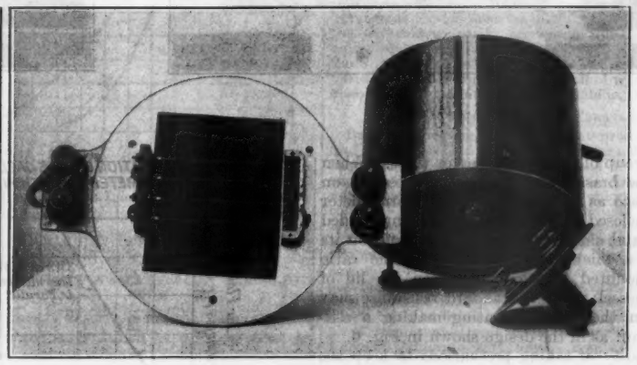


FIG. 5.

Fig. 5 shows the box dismounted and the anemometer wire withdrawn from the tube.[1] The anemometer wire is of 0·004-in. diam. platinum, having a total length, in four sections of 6 in. The volt thermometer is shown at one end of the box lid. It comprises four platinum wires each 0·004-in. diam. and 3 in. long, placed side by side. Connections are arranged on the lid of the box conveniently for putting two, three or four wires in parallel as required to obtain the maximum accuracy of reading over any particular range of air velocity.

It is important that the volt thermometer wires should be in still air, so the heat loss should be entirely by radiation and convection, otherwise the volt thermometer would become an anemometer. It will be seen from the figure that these wires are enclosed in a reasonably air-tight compartment of the box when the lid is closed. The walls of this compartment are fairly close to the heated wires, and it is found that for currents through the volt thermometer not exceeding 2·5 amperes with two wires in parallel the temperature condition of the walls surrounding the volt thermometer do not affect the volt readings on its terminals.

For measurements of high rates of air flow where the current through the volt thermometer may reach 5 amperes, it is necessary to surround the volt thermometer by a water jacket in order to keep the temperature conditions fairly constant in

spite of the comparatively rapid generation of heat. A water jacketed volt thermometer is shown assembled in Fig. 6 and dismantled in Fig. 7. The volt thermometer wires and their terminals are carried on an aluminium base plate. The base plate carries a brass vessel holding water and provided with a recess in its bottom large enough to

FIG. 6.

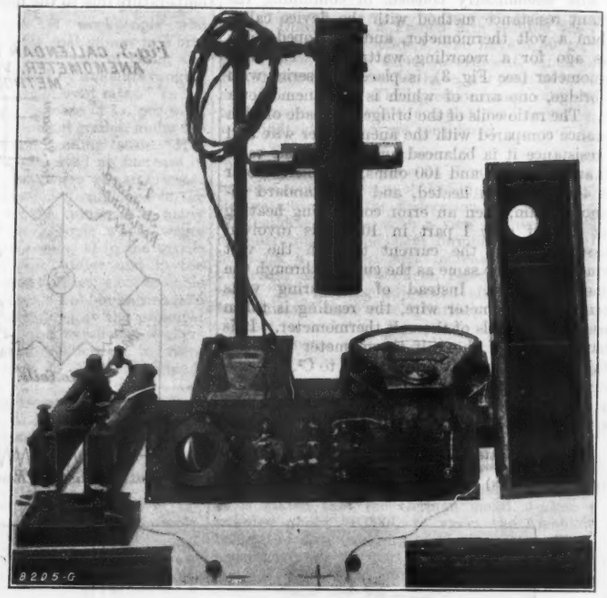


FIG. 7.

cover the group of volt thermometer wires. When therefore the brass water vessel is in position on the base plate as in Fig. 6 the volt thermometer wires are enclosed in an airtight space surrounded on its top and sides by a water jacket and on its bottom by a thick aluminium plate. The ratio coils are mounted for convenience on the lid of the brass vessel and the standard resistance may be fixed on the same mounting making a self-contained unit as in the design shown in Fig. 6.

The necessity of taking precautions to keep the walls surrounding the volt thermometer at a steady state of temperature became apparent when measurements were made of high rates of air flow requiring over 4 amperes through the volt thermometer. In such cases the calibration for the anemometer changes slightly for great differences of temperature of the surrounding walls of the volt thermometer. With the water-jacketed volt thermometer the calibration remains quite constant even when using up to 5 amperes through the volt thermometer.

Calibration of Callendar Hot Wire Anemometer.—The hot wire anemometer is not an absolute measuring instrument as already explained, and before it can be used for practical measurements it is necessary to determine the relation between various rates of air flow and their corresponding indications in volts on the volt thermometer. The anemometer may be calibrated to read air velocity under any special conditions from wind velocity in the open to mass flow in a pipe. Considering the latter case it is obvious that the anemometer must be calibrated for a particular position preferably in a particular piece of pipe. If the anemometer is so calibrated for mass flow the average velocity can be deduced from the area of cross section of the pipe, and for the usual practical measurements only mass flow or average velocity is required, the actual distribution of velocity over the cross section of the pipe not being of interest. It is also evident that an anemometer wire should be calibrated in conjunction with a particular volt thermometer, since the volts read on it for any value of the current through it will depend on the exact length and diameter of the platinum wires. The leads connecting the anemometer wire to the indicating

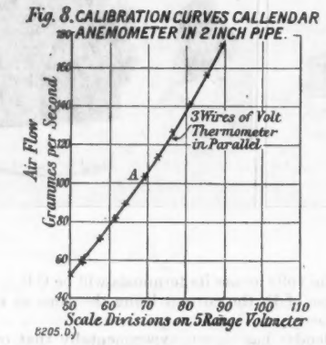
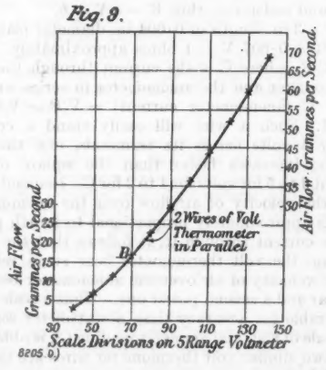


Fig. 8. CALIBRATION CURVES CALLENDAR ANEMOMETER IN 2 INCH PIPE.
Air Flow Grammes per Second
3 Wires of Volt Thermometer in Parallel
A
Scale Divisions on 5 Range Voltmeter
(8205.D.)



apparatus should also be included in the calibration. The air measurements required for calibrating the anemometer have been made with square edged orifices in thin plates, using Watson coefficients and the general methods in use at the Air Ministry Laboratory. These methods have been fully described (see "Measurement of Air Flow," R. O. King, ENGINEERING, April 13 and 20, 1923) and need not be further referred to here.

Fig. 8 shows calibration curves for an anemometer wire of 0·004 in. diam. platinum 6 in. long, made up of four equal lengths in series. This anemometer is inserted in the 2-in. diam. pipe shown in Figs. 6 and 7. The length of pipe is six diameters, and this proportion of length to diameter may be taken as sufficient to ensure that the cross sectional distribution of air flow does not change with the velocity. Referring to Fig. 8, the calibration made with two wires of the volt thermometer in parallel has been carried from a mass flow of 1½ grams per second to 67 grams per second corresponding to from 1·87 ft. per second to 83·3 ft. per second, average velocity in the pipe, which is actually 2$\frac{1}{16}$ in. inside diameter. The measuring orifices were changed as required to keep the pressure difference over them under 2½ in. of water in order that Watson's corrections for variation of discharge coefficients with pressure difference would apply. This required a total of seven different arrangements of orifices and is a good illustration of the inconvenience of using the orifice method of measurement over an extended range. The current through the volt thermometer and the anemometer wire varied from 1·23 amperes to 2·46 amperes and the volts on the volt thermometer from 1·0 to 4·7, that is, the volts increased faster than the square of the current as expected from the characteristics of the volt thermometer already described. It is due to this characteristic that the shape of the calibration curve lies between that of a parabola and a straight line, and is more favourable for accuracy of reading than if a watt-meter had been used.

The accuracy attained at any point on the calibration curve can be determined from the slope of the tangent at the point, this being equivalent to the method of differentiation already used in dealing with equations approximately representing the curve. For instance, at 57 scale divisions voltmeter reading the air flow is 10 grams per second and from the tangent, the rate of change of air flow with volts reading is 1 scale division per 0·50 grams per second air flow, and 0·50 grams is 5 per cent. of the 10 grams, so the percentage accuracy at 10 grams per second is 5 per cent. per scale division, and if readings can be taken to one-fifth of a scale division the actual accuracy at this point is 1 per cent. During the calibration, the volt-meter readings at the lower end of the range were particularly steady and could be made to one-tenth of a division. This is shown also by the very smooth curve on which the observed points fall.

However, for the purpose of carrying the calibration below 10 grams per second more accurate results would have been obtained by using a single wire of the volt thermometer, but as measurements of less than 10 grams per second were not proposed the volt thermometer was not arranged for less than two wires to be used.

At the highest reading taken the percentage accuracy works out at 1·4 per cent. per scale division and reading to one-fifth of a scale division the possible accuracy is one-third of 1 per cent. Similarly at 20 grams per second the accuracy attainable is three-fifths of 1 per cent. The best range for this anemometer in a 2-inch pipe would then be from 20 to 65 grams per second, with an accuracy of half of 1 per cent. at the lower end of the range extending to one-third of 1 per cent. at the upper end, this using two wires of the volt thermometer in parallel. Then without changing the voltmeter, the range can be lowered to read below 20 grams per second by shifting to a single wire or raised to read above 65 grams per second by changing to three wires in parallel, and readings taken on these extensions of the range would have the same degree of accuracy as found for the middle range of 20 grams to 65 grams per second.

The calibration, Fig. 8, for three wires of the volt thermometer extends from 50 grams per second corresponding to an average velocity of 60 ft. per second, to 170 grams per second corresponding to approximately 200 ft. per second average velocity. The attainable accuracy deduced from the experimental curve is half of 1 per cent. on readings to one-fifth of a scale division, at an air flow of 120 grams per second, which as expected, is a similar order of accuracy to that obtained on the lower range calibration. It will be noted that the calibration has not been carried to the full range of the voltmeter scale, the highest mass flow being approximately 172 grams per second for 90 scale divisions on the voltmeter. If greater mass flows were to be measured it would be advisable to calibrate the anemometer in a larger diameter pipe in order to keep the velocity in the pipe below 200 ft. per second, this being the safe limit for a 0·004-in. diam. platinum wire 1½ in. long and heated to a temperature corresponding to 4 ohms resistance.

Should it be necessary at any time to measure mass flows at higher velocities than 200 ft. per second it is quite simple to adapt the Callendar apparatus for use with larger diameter anemometer wires than 0·004 in., and in fact this has been done to meet special conditions occurring in the course of the work of the Air Ministry Laboratory.

Comparison of Callendar Hot Wire Anemometer with other Methods from Experimental Results.—Earlier in this article the accuracy to be expected from the constant resistance anemometer, the Callendar anemometer and the orifice method, was deduced from the approximate equations connecting the rate of air flow with the quantity observed, for each case. It is now possible to confirm the deductions made, from experimental results. Referring to Fig. 10, B is a calibration curve for a German design of measuring orifice for which it has been claimed that the coefficient of discharge is nearly unity and remains constant for differences of pressures over it up to 12 inches of water. It was found that unsteadiness of the pressure difference over the orifice made it impossible to rely on making readings closer than half-a-tenth of an inch at the most favourable part of the scale. On this basis the attainable accuracy at 10 grams per second is 7½ per cent., at 35 grams per second it is three-quarters of 1 per cent. and at 65 grams per second it is one-quarter of 1 per cent. It is seen that a very favourable degree of accuracy is reached for the maximum reading down to half of this amount, a very limited range. This special orifice was calibrated in the process of determining its coefficient of discharge over the range shown by the calibration curve. Though it is claimed for the orifice that assuming its coefficient of discharge to be unity gives sufficiently accurate measurements for practical purposes, it was found that the coefficient varied from 6 per cent. less than unity at 10 grams per second to 3 per cent. less at 65 grams per second.

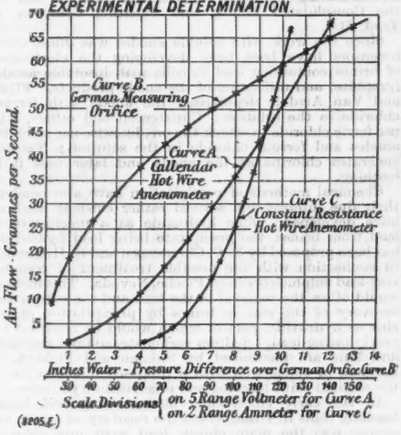
In Fig. 10, C is a calibration curve for the constant resistance hot wire anemometer based on the relation between the rate of air flow in grams per second and the current through the anemometer wire in amperes. Assuming that the ammeter can be read to one-fifth of a scale division the accuracy attainable at 10 grams per second is 2 per cent., at 35 grams per second it is 1·1 per cent. and at 65 grams per second it is 0·8 per cent.

The accuracies attainable by the three methods described as determined from these experimental results are tabulated below :—

Method of Measurement.	Air Flow in Grams per second.		
	10	35	65
	Attainable Accuracy.		
German Orifice:	Per cent.	Per cent.	Per cent.
Reading to $\frac{1}{10}$-in. on Manometer	7½	0·75	0·25
Constant Resistance Anemometer:			
Reading to ½ division on Ammetre.	2	1	0·8
Callendar Anemometer:			
Reading to ½ division on Voltmeter.	1	0·4	0·33

The German orifice is typical of any orifice method as far as attainable accuracy and range of measurement is concerned and only differs from other orifices in shape. In the trials it was necessary to use an orifice of less than 1½ in. diam. in a 4-in. diam. pipe, to measure mass flow up to only 65 grams

Fig. 10. ATTAINABLE ACCURACY OVER SAME RANGE FOR THREE METHODS OF AIR FLOW MEASURMENT EXPERIMENTAL DETERMINATION.


Curve B.
German Measuring Orifice
Curve A
Callendar Hot Wire Anemometer
Curve C
Constant Resistance Hot Wire Anemometer
Air Flow - Grammes per Second.
Inches Water - Pressure Difference over German Orifice Curve B
Scale Divisions
on 5 Range Voltmeter for Curve A
on 2 Range Ammeter for Curve C

(8205.£.)

per second.. This upper limit is reached with a difference of pressure over the orifice of 12-in. of water and the accuracy is high over only a small part of the range.

The experiments described for the Callendar hot wire anemometer in a 2-inch pipe, show that by using one, two or three wires of the volt thermometer an order of accuracy of measurement of half of 1 per cent. can be obtained for mass flows of from 1 gram per second to 170 grams per second, no appreciable obstruction is placed in the air stream and a single instrument, a five-range voltmeter, covers the entire range.

APPENDIX.

List of References to Work on Hot Wire Anemometry.

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THE FIRST PRINCIPLES OF LIFTING MACHINERY.—This is the title of an illustrated pamphlet of 40 pages, issued at the price of 2*s.* by the Technical Section of the Association of Engineering and Shipbuilding Draughtsmen. The work is by Mr. G. T. Smith, member.

HYDROMETALLURGY OF LEAD.*

By OLIVER C. RALSTON, Berkeley, California.

A DEFINITE field of usefulness has developed for the brine-leaching processes of removing lead from ores and other products, so this paper reviews the developments, both in practice and in research, that have taken place since the publication of two earlier American papers on this subject in 1917 and 1918. Several commercial plants are now in operation and a number of semi-commercial test plants have been operated in an effort to determine the limitations of brine leaching and to compare the results with other forms of treatment.

Briefly, the brine leaching of lead depends on the fact that lead chloride and lead sulphate are soluble in saturated sodium-chloride solutions. In dilute brines, the solubility of the lead salt is less than in pure water; but in the strong brines, the solubility is greater than in pure water due, supposedly, to the formation of a double sodium-lead chloride.

The paper then deals with the Demassieux diagram and with the effect of temperature on the solubility of lead chloride in brines. A weak brine has not sufficient dissolving power, and a strong brine cannot be prepared except at the expense of throwing lead chloride out from solution.

Although the addition of sulphates to most solutions of lead will form an insoluble precipitate of lead sulphate, this is not true for brines; in fact, lead sulphate can be dissolved by the brine, apparently it is altered to lead chloride and the sulphate radical combines with sodium. An accumulation of sodium sulphate in the solution is not desirable, as it allows less sodium chloride to stay in solution and to that extent dilutes the effective leaching solutions.

A strong brine also dissolves cuprous chloride and silver chloride, both of which are practically insoluble in water. Quantitative figures are not available for cuprous chloride but the solubility for silver chloride in strong brines has been determined by Forbes. For the strong brines, about 1 oz. of silver will be extracted by 1 cub. ft. of brine. Proper proportioning of solution to ore in order to extract all of the silver can be made on this basis; for most ores, the ratio necessary to extract all of the lead gives a great margin of safety for the silver.

Whereas the lead can be dissolved in a natural brine, the silver is so easily precipitated from the solution on such substances as zinc sulphide that almost invariably the brine must also contain small amounts of acid or of ferric chloride or cupric chloride, all of which tend to redissolve any precipitated silver sulphide.

PRODUCTS REQUIRING TREATMENT.

Brine leaching can be used for any product containing lead chloride or lead sulphate and silver chloride or silver sulphate. Acidified brines also tend to attack galena and the sulphide minerals of silver, especially if the solution also contains the higher chlorides of iron or copper. A brief review of the products to which the brines have been adapted is given.

1. *Electrolytic Zinc Plant Tailing.*—Most of the lead originally present in the ore is present in this tailing as sulphate; part of the silver and much of the copper also are in a soluble condition. On that account, rather large sums of money have been spent in testing the adaptability of brine leaching to the treatment of zinc-plant tailing at Great Falls, Montana, Trial, B.C., Kennett, California, and Hobart, Tasmania.

2. *Lead-Sulphate Flue Dust from Lead and Zinc Smelters.*—The application of brine leaching to treatment of this product has been tested at a number of smelters and by several inventors. As is well known, lead smelters cannot normally treat large percentages of lead sulphate dust and always try to avoid it or at least not to allow the percentage used in the blast-furnace charge to rise above a rather low figure.

3. *Lead-Sulphate Sludges from Sulphuric-acid Chambers.*—The lead of the chamber walls is gradually sulphated (3 lb. lead per ton acid produced) and it is common practice to clean out and repair the lead chambers every three or four years and ship the lead sulphate sludge to a lead smelter, if one is within economic distance.

4. *Oxidised Ores of Lead containing Lead Carbonate or Lead Sulphate.*—If these ores do not contain too much limestone or other acid consumers, an acidified brine (containing sulphuric acid) can be used for the extraction of lead carbonate whereas a neutral brine will extract the lead sulphate from almost any ore. This is being tested on river accumulations of tailing by the Bunker Hill and Sullivan Mining, Smelting and Concentrating Company in Idaho and has been investigated by several other companies. Silver ores containing oxidised minerals of lead are given a chloridising roast at two plants in Utah and the lead is recovered from the ore, together with the silver, by the use of brines.

5. *Concentrating Mill Tailing containing Lead Sulphide or Silver Sulphide, or Both.*—This type of material is receiving serious attention by the Bunker Hill and Sullivan Company.

6. *Complex Zinc-Lead-Iron Sulphide Ores.*—Numerous methods of chloridising and brine leaching have been invented and tested. Nearly all of the large companies in the world that produce large amounts of zinc-sulphide concentrate containing lead have investigated various chloride-volatilisation processes or brine-leaching processes for the removal of the lead and silver.

METHODS OF CONVERTING LEAD TO SOLUBLE FORM.

For oxidised ores, as just mentioned, lead sulphate is directly soluble in the brine and lead carbonate is soluble in acidified brine. Oxidised ores also yield to either

* Abstract of a paper read at the New York meeting, February, 1924, of the American Institute of Mining and Metallurgical Engineers.

sulphate or chloride roasting preceding a brine leach. Methods of treatment that also form ferric chloride or other multivalent chlorides in the solution are also applicable to lead carbonate, as the latter reacts with ferric chloride, precipitating basic ferric chloride or ferric hydroxide and giving off carbon dioxide so that the lead goes into solution as lead chloride. Chloridising roasting with salt in a shaft roaster is practised at two plants in the Tintic district of Utah.

For sulphide ores, one of the simplest things to do is to give a low temperature roast (400 deg. to 550 deg. C.), under which conditions the galena is sulphated easily and almost completely. This was investigated and reported by the Bureau of Mines in previous papers. A cleverly designed roaster for this purpose is now being developed at the Bunker Hill and Sullivan plant.

Chloridizing roasting of lead-sulphide ores containing silver is another favourite method and patent literature is full of processes that are variations of this idea. It was reported upon both by the Bureau of Mines and by Larson who worked for several years at Kellogg, Idaho, with a simple lead-silver ore. The use of zinc chloride instead of sodium chloride for heating with complex sulphide ore is advocated by Ganelin and by the Amalgamated Zinc (De Bavay's), Limited, of Australia, as well as by Harry Hey, formerly of the Amalgamated Zinc but later of the Electrolytic Zinc of Australia, Limited. Heating the ore in an atmosphere containing hydrochloric-acid gas is advocated by the Amalgamated Zinc and by Hey, galena being chloridised before sphalerite. This chloridising-roasting treatment converts the lead to a soluble form satisfactorily, but one important function of the chloridising roast is to convert any silver compounds in the lead ore to the chloride form so that the silver chloride may also be extracted with the lead chloride or sulphate by a brine. Heating with ferric or cupric chloride to 150 deg. to 250 deg. is advocated by Middleton in order to chloridise the silver. Chloridising roasting with chlorides of calcium or magnesium at 400 deg. to 500 deg. C. is advocated by F. E. Elmore, using moist air to generate hydrochloric acid by interaction with the alkaline-earth chloride in the charge. A temperature of over 500 deg. C. cannot be allowed as the zinc sulphide is attacked at higher temperatures, but below it the galena is selectively chloridised. Selective chloridising roasting with salt is advocated by H. J. E. Hamilton, of Broken Hill, who keeps the roasting temperature below 400 deg. C. in order to chloridise lead and silver selectively without affecting the zinc content of the ore.

Sulphuric acid treatment of mixed sulphide ore is proposed by several inventors. Elmore uses strong acid (1·84 specific gravity or 95 per cent. H_2SO_4) at about 100 deg. C., under which conditions the galena is converted to lead sulphate with liberation of sulphur dioxide and elemental sulphur and the zinc and other sulphides in the ore are largely unaffected. Christensen has developed a very similar treatment of the ore that produces almost the opposite result. By using acids from 60 to 98 per cent. in strength and heating to their boiling points, the zinc sulphide is attacked and converted to sulphate which is soluble in excess of the concentrated acid. With acids stronger than about 80 per cent., elemental sulphur and sulphur dioxide are evolved and galena is sulphated. With weaker acids, hydrogen sulphide is the main sulphur product and galena is not attacked while the sphalerite is. P. A. Mackay uses fuming sulphuric acid containing considerable dissolved sulphur trioxide to attack the galena and convert it to sulphate.

Strong hydrochloric-acid solution, when heated, will attack galena in preference to sphalerite, according to Elmore, with evolution of hydrogen sulphide.' However, the difficulties of heating by hydrochloric acid in any commercial material of construction are so great that this method will not be of great interest.

Dilute hydrochloric-acid solution, in the form of a slightly acid saturated sodium-chloride brine, is recommended by Elmore, who adds sulphuric acid to the ordinary brine used in leaching soluble forms of lead; when heated close to the boiling point this solution attacks the galena with evolution of hydrogen sulphide leaving the zinc sulphide largely untouched. Sulphuric acid is used because it is cheap, but means must be taken for preventing deleterious accumulation of sulphates in the brine. Some of the silver in the ore is also dissolved, especially if hydrogen sulphide is removed as fast as formed. The early work by the Bureau of Mines was with acid brines as applied to oxidised ores. Although desultory experimenting was known to the author, Elmore seems to be the first to have published anything on the use of these brines with raw sulphide ore; since then numerous inventors have worked with these brines and the patent literature resulting is extensive.

Ferric chloride, usually dissolved in a strong brine of NaCl or of $CaCl_2$, has been experimented with by several organisations on a relatively large scale, and seems to be well adapted to removing lead and silver from complex sulphide ores. Usually the solution must be heated in order to make it attack the lead and silver minerals vigorously. The sulphur of the galena is liberated as free sulphur. Perhaps the most work has been done by Hanney, Collins and Christensen. Hanney worked at the plant of the Consolidated Mining and Smelting Company, of Trail, B.C. Collins is an English inventor and Christensen has been identified with chloridising roasting and leaching of silver-lead ores in Utah for ten years. Brines containing ferric chloride are more widely used for leaching prepared ore than for attacking raw ore.

Leaching Solutions.

A neutral saturated brine of sodium chloride, or a strong brine of calcium chloride or magnesium chloride, will dissolve lead chloride, lead sulphate, and silver chloride, so that they may be leached from the ore. Silver is so easily precipitated on other sulphide minerals that its leaching solutions must be acidified or carry some ferric chloride, which redissolves any silver metal or silver sulphide that tends to precipitate; its use is fundamental to the processes of the Amalgamated Zinc (De Bavay's), Limited, of Australia, of Christensen and of others.

A chloride solution containing excess chlorine is used by Nathansohn in order to take the lead chloride into solution as the more soluble tetrachloride of lead. A leaching solution of brine containing smaller amounts of chlorine is used in the Tainton process at the Bunker Hill and Sullivan test plant, Kellogg, Idaho, in order to take lead and silver into solution and prevent reprecipitation.

Ferrous-chloride solution containing 12 per cent. ferrous chloride, which is capable of taking up 3 per cent. of lead chloride at 90 deg. C., is used by DeLuce, who uses ferrous chloride in place of sodium chloride, in spite of the lower dissolving power, to follow an attack of the ore by a 15 per cent. ferric-chloride solution, and he thus avoids trouble due to the mixing of the two solutions.

Precipitating the Lead.

The early work of the Bureau of Mines seemed to indicate that electrolytic precipitation in a cell with iron anodes would be economical and satisfactory. This method was tested on a fairly large scale by the Anaconda Copper Mining Company at Great Falls, Montana; by the Bunker Hill and Sullivan Mining and Concentrating Company at Kellogg, Idaho; and by the Consolidated Mining and Smelting Company at Trail, B.C.

Since the work with soluble anodes was done, other inventors have been busy developing the electrolysis of brines containing lead in cells with insoluble anodes (graphite) and utilisation of the anode products. Flynn and Van Arsdale depolarised the anode with ferrous chloride in the solution; Christensen and others, who use ferric chloride to attack the ore, likewise use insoluble anodes and ferrous chloride in the solution; Tainton generates chlorine at the anode and later uses it in leaching.

Chemical methods of precipitation have also received their due interest and several rather efficient methods have developed. Zinc hydroxide as a precipitate of lead from brines, the precipitate being lead hydroxide, has been proposed by N. C. Christensen and E. H. Snyder, in connection with the possible treatment of complex zinc-lead sulphide ore from Pioche, Nevada. This method would allow the removal of the lead and the subsequent recovery of the zinc in brines by precipitation of the zinc as hydroxide, part of which would be returned for precipitating lead. Sodium carbonate, sodium sulphide, and lime are mentioned by Sulman and Pickard, of London, in connection with a proposed modification of the original brine leaching and precipitation processes.

In the early chloridising blast-roasting and brine-leaching mills in Utah, where the recovery of silver and copper was the main object, lead went into solution and part of it was precipitated on the scrap iron used for recovery of the silver and copper, after these two metals had been removed from the solution. This precipitation on scrap iron is very slow at ordinary temperatures, but is more rapid if the temperature of the solution is raised. This fact has been utilised in the chloridising leaching mill of the Tintic-Standard Mining Company at Harold, Utah. The need of using hot brines makes working uncomfortable, and there is some difficulty in cleaning up the precipitated lead.

Sponge iron as a precipitant of lead from brines was probably first experimented with on a relatively large test at Kennett, California, in the electrolytic-zinc plant of the U.S. Smelting, Refining and Mining Co. by H. R. Hanley, in connection with the recovery of lead from zinc-plant residue. T. P. Holt has recently operated a commercial plant in the mill of the Tintic Milling Company at Silver City, Utah, producing sponge iron by a process developed at the Northwest Experiment Station of the Bureau of Mines and using it in recovering lead from leaching solutions. Sponge iron, different from scrap iron, will precipitate the lead as a spongy metal at practically room temperature, and does not require heating of the solution to the temperature needed by scrap iron. The precipitation is rapid and practically complete. As used at Silver City it is placed in beds in long launder-shaped boxes and the solution passed down through it. It can also be pulverised like zinc dust and applied, in the same way that zinc dust is used in cyaniding, for the precipitation of lead, copper, silver, and gold from brine-leaching solutions.

Users of Brine Leaching.

The foregoing shows that brine-leaching methods have received wide attention and a number of commercial plants are in operation. In Australia, the Amalgamated Zinc (De Bavay's), Limited, some of whose inventors are David Avery and Harry Hey, and the Electrolytic Zinc Company of Australasia, Proprietary, Limited, have been interested. H. J. E. Elmore and the Chemical and Metallurgical Corporation, of London, have been very busy, paying particular attention to the complex ores of the Burma Corporation. Sulman and Pickard, H. S. Mackay, P. A. Mackay, J. J. Collins, J. Nelson, and M. C. White are also contributors to the advancement of the art.

In Germany, F. Krupp and A. Nathansohn have carried out research work.

In Canada, at Trail, B.C., the Consolidated Mining and Smelting Company has done considerable work in treating the zinc-leaching plant residues, and an important improvement has been patented by one of its men, W. H. Hannay.

In the United States, a plant is in operation by the Tintic Milling Company, of Silver City, Utah; another plant is in operation by the Tintic-Standard Mining Company at Harold, Utah; fairly large test plants have been built and operated by the Bunker Hill and Sullivan Mining, Concentrating and Smelting Company at Kellogg, Idaho (J. L. Malm, R. S. Handy, C. L. Larson, W. G. Woolf, and U. C. Tainton); by the Anaconda Copper Mining Co. at Great Falls, Montana (J. O. Elton and R. B. Caples); the U.S. Smelting, Refining and Mining Co. at Kennett, California (H. R. Hanley). Smaller-scale experimental work has also been carried on by the Butte and Superior Mining Co. at Butte, Montana; the Philipsburg Mining Company at Philipsburg, Montana; S. Ganelin of Brooklyn, N.Y.; N. C. Christensen, of Salt Lake City, Utah; Francis N. Flynn and G. D. Van Arsdale, of New York; P. R. Middleton, of New York; Robert DeLuce, of Oakland, California; and others.

Spence Process.

One of the earliest attempts at treatment of lead ores by hydro-metallurgical means was that of Spence, of England, reported by Collins. Slime of a complex sulphide ore, containing 48 per cent. zinc and 14·7 per cent. lead, was treated with 100 gallons commercial muriatic acid per ton ore and the resulting lead chloride washed out with 12 tons hot water, leaving a residue containing 2 per cent. lead and 57·5 per cent. zinc. Two-thirds of the lead precipitated from the hot water on cooling and the remainder was recovered as lead-chromate pigment by adding chromates to the solution. This process was worked for several years but commercially was unsuccessful; the reasons for this, however, have not been stated.

Holt-Christensen Process.

Since 1914 mills in Utah have been using processes that grew out of the work of T. P. Holt and N. C. Christensen, all of which involved chloridising roasting in blast roasters, followed by leaching with brine. Silver and copper have been the two metals sought, but it has always been recognised that the brines were saturated with lead. Precipitation of the silver and copper has taken place on scrap iron and at the temperature of the mill solutions (20 deg. to 35 deg. C.) very little of the lead in the solution was precipitated. In fact, lead does not begin to precipitate until most of the silver and copper have been cemented on the iron. Intermittent attempts were made to develop a cheap way of recovering the lead, but it was not until the high prices of lead in 1922 and 1923 that any of the methods of precipitation that had been developed were adopted in practice. At present, that portion of the lead which happens to dissolve is recovered in the mills of the Tintic Milling Company and of the Tintic-Standard Mining Company.

(To be continued.)

THE ECONOMICAL THICKNESS OF INSULATION IN REFRIGERATOR CARS.*

By Arthur J. Wood, State College, Pa., Member of the Society, and Philip X. Rice, Danville, Ill.

(Concluded from page 218.)

Discussion of Factors Involved.

21. There are not many factors involved other than those named which affect the choice of insulation. Moreover, most of those listed are subject to variation in characteristics difficult to evaluate. Further consideration may be given to the factors mentioned early in the article and these will be taken up in the order as listed.

(*a*) Thickness of insulation may not conform to exact specified thickness. This is particularly true of hair felt.

(*b*) Price per actual board foot may not conform to quoted price on account of discrepancy in thickness.

(*c*) Fixed charge, in per cent., includes maintenance and depreciation which change with successive improvements in construction and operation, and is somewhat difficult to determine accurately for any particular installation.

(*d*) The conductivities of most of the insulating materials have been determined for certain conditions, but unless the engineer knows something of the properties and characteristics of materials and the conditions under which they were tested, he may be misled in using tabular values.

The conductivity of a given piece of insulation is almost certain to lose some of its thermal resistance in service. During the process of installation, the material may be crushed or stretched or fail to fit closely enough to prevent convection through the wall or part of the wall. In service, the wall insulation may become detached in places and break the continuity of the material. From an inspection of hundreds of cars the authors concluded that usually car floors and the lower part of walls are soaked with water. Superintendents of refrigerator service admit that floors and lower walls are the least satisfactory. Unless steel floors are used, it would be safer to assume that the floor insulation will be wet and the conductivity should be chosen accordingly. In the case of yellow pine, the authors found that the conductivity of wet wood was about twice as much as that of dry wood. With insulating materials, the variations due to moisture content are not known and the true values cannot be used until some laboratory has determined the effect of moisture. For imperfectly protected floor insulation the authors suggest that conduc-

* Paper read at the New York meeting of the American Society of Mechanical Engineers, December, 1922.

tivity be doubled for economic calculations. A certain railroad built two milk cars with watertight, rust resisting steel floors; probably the reduced maintenance cost would justify such construction independently of the considerable saving in ice.

(*e*) In general, the conductivities of other structural parts of a car cannot be determined accurately, but ordinarily the thermal resistance of such parts is such a small part of the entire wall or floor that some tolerance of conductivity is permissible. As mentioned before, the thermal resistance of wood depends largely on its moisture content and probably, for unprotected floors, should be taken as half the resistance of dry wood. Other structural materials often have less insulation value than is shown in tables for conductivity.

(*f*) Resistance of an air space is difficult to predict unless it is known to be strictly airtight. For stationary cold-storage walls, ordinary cracks would not be as objectionable as in moving cars. It has not been determined how tight an air space must be in order to be effective. Surface resistance is such a variable that the safe procedure is to use a value of zero for the outside surface of cars when the air passes over the surface at a speed of more than 10 miles per hour. If the resistance of the car wall proper is relatively high, as in modern refrigerator cars, the outside surface resistance can be neglected with but slight error in the total transmission through the wall. It is better to use some approximation of the outside surface resistance, taking into account the velocity of air on the surface. The inside surface resistance amounts to more than that of the outside, and ordinarily where the air is fairly calm, the surface resistance can be predicted closely enough for thick walls where an error in the surface resistance would not affect seriously the total transmission.*

(*g*) Differences of temperature between the outside and the inside of the car should be determined by actual measurements; if that is not possible, it can be approximated by aid of recorded tests of similar cars, provided it is known where the temperatures have been observed. The following may assist in this approximation: the floors of end-bunker cars are often 20 deg. to 35 deg. colder than the ceilings. It is desirable to use the temperatures taken at least 2 in. from the car surface and to include surface resistances in the calculations.

Outside shade temperatures can be predetermined approximately by the temperature maps, Figs. 6, 7, and 8 which show July, January, and annual shade temperatures. These apply to outside wall and floor temperature but are somewhat too low because the walls receive direct radiation from the sun on bright days and floors receive some radiation from hot ballast. In the case of roofs, especially black or red roofs, the error of neglecting radiant heat is appreciable, as is brought out in Fig. 9. The authors have found that at noon, summer or winter, at any latitude, there is a difference of about 62 deg. between shade and either black- or red-roof temperatures,* provided the sky is clear and the roof is perpendicular to the sun's rays. If the roof is in a horizontal position, the variation in temperature increment above shade temperature is shown in Fig. 9 by the broken lines for August, October, and December. For an integrated average covering a period of 24 hours' fair weather, the increments obtained are 20·4 deg. in August, and 17·5 deg. in October, or 17 deg. annual. The corresponding increments for white roofs are only 7·6 deg., 5·6 deg., and 5·5 deg. It can be seen that if the railroads would paint their car roofs white, as some paint the walls, considerable less ice would be required. However, the 20·4-deg. average for August for black roofs applies only for still air in clear weather. Refrigerator cars stand still only about 40 per cent. of the time they carry ice, and much of the other 60 per cent. they run at speeds above 10 m.p.h. above which speed the temperature increment is negligible.

Furthermore, the natural wind velocity is often greater than 10 m.p.h., so that one should not expect to experience more than 40 per cent. of 20 deg. = 8·2 deg. average effective increment. For stationary cold-storage buildings the effective increment in August would probably be 15 deg. to 18 deg.

By aid of the diagrams of Figs. 6 to 9, inclusive, one is able to reach fairly accurate results for outside average-temperature conditions in different parts of the country and for different conditions under which the sun strikes the surface. The inside temperatures may be approximated as indicated, making it possible to determine with reasonable accuracy the average temperature differences.

(*h*) The correct figure for the percentage of year in which a refrigerant or a heater is used should be determined on the car-day basis; that is, if only a few cars are refrigerated in winter and all the cars are refrigerated for three months in summer, the figure would be slightly over 3/12 = 25 per cent. This is sufficiently close for ordinary refrigerator-car service, but for special industries, such as meat packing, the figure may be 30 per cent. In the case of cold storage the figure is generally much higher.

(*i*) The price of ice for refrigerator cars can be found readily by referring to the regular charges made at icing stations, ordinarily about 4 dol. per ton. In cold-storage plants the cost of producing and delivering refrigeration to the storage rooms can be determined most accurately by referring to the construction, maintenance, and operating costs of the plant; probably the cost is less than 1 dol. per ton of ice (equivalent refrigeration). It may be noted that the cost of absorbing heat by refrigeration or by ice is many times more expensive than supplying that much heat by heaters. Therefore, the cost of supplying heat to refrigerator cars in winter is almost negligible in comparison with the cost of refrigerating the same cars in summer; the economic thickness of insulation should therefore be determined by the refrigeration.

(*j*) *See* comment on thickness in paragraph (*a*) above.

(*k*), (*l*) and (*m*) have been covered by the discussion in previous paragraphs.

22. It should be apparent to those who have followed the discussion, that the most intricate problems of economic thickness of insulation may lend themselves to a satisfactory solution if full information is obtained concerning the factors involved.

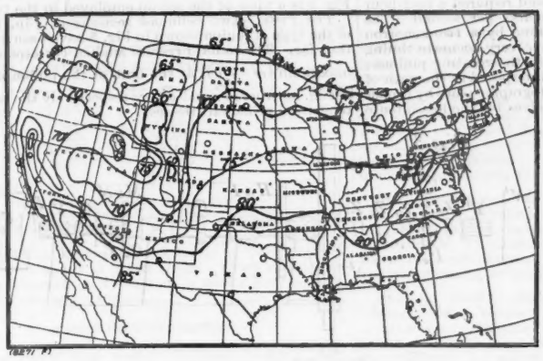


FIG. 6. AVERAGE JULY SHADE TEMPERATURE.

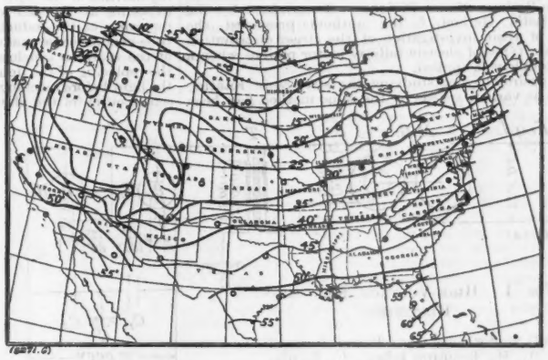


FIG. 7. AVERAGE JANUARY SHADE TEMPERATURE.

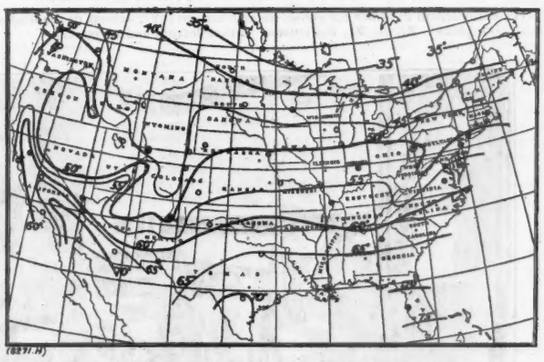


FIG. 8. AVERAGE ANNUAL SHADE TEMPERATURE.

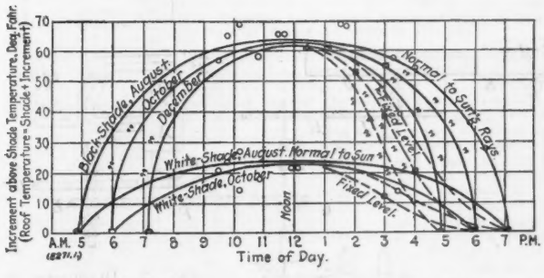


FIG. 9. ROOF-TEMPERATURE CORRECTIONS, INCREMENT ABOVE SHADE TEMPERATURE.

* This is further discussed in an article by A. J. Wood on "Insulation of Passenger and Refrigerator Cars," in *Railway Mechanical Engineer*, September, 1921.

* This value of temperature increment is approximate—the average of many readings of mercury thermometers.

STANDARDISATION OF COLLIERY REQUISITES.—The British Engineering Standards Association, at the request of the Mining Association of Great Britain, has undertaken the standardisation of colliery requisites. A fully representative committee is being set up under the chairmanship of Mr. Evan Williams, president of the Mining Association, who are contributing to the funds of the B.E.S.A., to enable this important work to be carried out on an adequate basis. Local committees are to be instituted in the various centres, and in order that concrete results may be obtained without undue delay the local committees will concentrate their attention at first on a limited number of the more important items, such as pit tubs, rails, rope sheaves, of which there are a great variety of types in existence. Interchangeability in these and other standards will make for ease of replacement and quick delivery. Both the Mining Association and the B.E.S.A. are to be congratulated on the promotion of this co-operative movement.

LONG RUNS ON SOUTHERN PACIFIC.—The Southern Pacific Company has recently inaugurated in regular service a conspicuous example of the prevailing tendency toward longer locomotive runs, says *Railway Review*, Chicago. The runs cover the distance between El Paso, Texas, and Los Angeles, California, without change of engines. The engines assigned to this duty comprise 10 4-8-2 type passenger locomotives which were designed by the company's mechanical department especially for hauling heavy passenger trains in this service. These locomotives are now regularly hauling the "Sunset, Limited," with 12 cars, and other high-class passenger trains between Los Angeles and El Paso, over the Los Angeles and the Tucson divisions, 815 miles, without change of engines and without banking engines. The maximum gradients are on the Los Angeles division. From Colton to Beaumont, eastbound, the gradient is 1 in 50, over which the train runs 24·2 miles per hour. From Indio to Beaumont, westbound, the gradient is also 1 in 50 and the speed is 26·2 miles per hour. On the balance of the run the speed averages 37·6 miles per hour, eastbound, and 36·4 miles westbound. The present timetables give the locomotives 24 hours standstill for boiler washing and inspection at the two termini. The engines average 12,000 miles per month. The engine cylinders are 28 in. diameter and 30 in. stroke. The driving wheels are 73 in. diameter. The boiler pressure is 210 lb. They are equipped with superheaters, Worthington feed water heaters and Franklin boosters. The tractive power with booster is 67,660 lb. and without booster 57,500 lb. The tender capacity is 4,000 gallons of fuel oil and 12,000 gallons of water.

STRESSES IN GEAR PINIONS.

*Stress Distribution in Rotating Gear Pinions as determined by the Photoelastic Method.**

By PAUL HEYMANS, Cambridge, Mass., and A. L. KIMBALL, JR., Schenectady, N.Y.

IN a previous paper entitled "Stress Distribution in Electric-Railway Motor Pinions as Determined by the Photoelastic Method,"† the authors presented the results of their investigation of the stress distribution in certain types of electric-railway motor pinions when a static couple was applied.

The desirability of studying the stresses in rotating pinions at various speeds by the same method has been recognised by the authors since the beginning of their work, and was furthermore mentioned during the discussion of the above-named paper. A method which has been developed to accomplish such an investigation is described in the following paragraphs and some preliminary results obtained by its use are given.

A later paper will give particulars regarding a more thorough investigation, now in progress, of the stresses in gear teeth at different speeds of rotation.

The authors acknowledge with thanks the valuable co-operation of Messrs. W. Dietz and T. H. Frost.

Description of the Apparatus Employed.—In order to measure by means of the photoelastic apparatus the stress at a given point of a rotating pinion that is shrunk on to a shaft and is transmitting torque, it is necessary to obtain a coloured photograph of a tooth while it is in motion. Since the coloured image is continually changing as the tooth passes through the field of view, there is but one instant during each revolution of the pinion when the stress distribution in a particular tooth repeats itself. Therefore, by using an electric spark to furnish illumination at just this instant during each revolution, and by projecting the repeated image upon a sensitised plate of the proper type a colour photograph can be obtained provided the sparks recur with sufficient frequency.

A static induction machine was first used to obtain sparks, but was found to be too much subject to oscillatory effects, due mainly to temperature, moisture, and the ionised condition of the surrounding atmosphere. A kenotron rectifier—a high-voltage condenser set, described later—solved the problem, evenly recurring sparks being obtained up to a frequency of 20 per second.

The electric-spark spectrum, however, differs considerably from the spectrum of the mazda lamp previously used, in that it has a predominance of blue-violet and ultra-violet radiation. The use of the spark in this photoelastic investigation was necessarily preceded by the analysis of the spark spectrum with electrodes of different kinds. The proper light filters and the sensitising solutions for the autochrome lumière plates, used in the recording of the stress distribution in the photoelastic analyses, had also to be developed.

The first tests, carried out with a 40,000-volt to 70,000-volt spark obtained by aid of a 40-in. glass-disc static induction machine, were tedious on account of the irregularities of the light source, and required a four-hour exposure at the rate of two sparks per second. The replacing of the induction machine by a two-kenotron tube-condenser set made possible a very accurate timing of the spark in synchronism with the rotating pinions; the replacing of the light filters interposed in the path of the light before reaching the photographic plate by proper sensitisation of the plates themselves for the less intense parts of the spectrum of the spark, brought the exposure down to 500 sparks, that is, to about four minutes at the rate of two sparks per second.

Fig. 1 is a diagrammatic representation of the kenotron-condenser apparatus and the connections employed. Fig. 2 is a diagrammatic plan view of the driving arrangement for the gear models and the means of applying known and constant loads to the models when rotating.

Referring to Fig. 2, the speeds of rotation of the gears H and I which were being tested were controlled by the spur gears C and D. A chain drive F was used to connect the sprockets E and G, as it gives a positive drive but not too rigid a coupling. The celluloid gear H drove the celluloid gear I which was mounted on an expansion ring that allowed the application of radial shrinking pressure. On the same shaft with I was a band brake J and dynamometer by means of which a known resisting torque could be applied to the gears.

The reproduction of conditions of contacts was secured by the aid of a sighting telescope W which made it possible to line up the sighting arm K with the fixed index L, resulting in the synchronous working of the spark and contact of the gears at chosen points.

The revolving arms R controlled the spark, their gap being in series with the electrodes. The frequency of the spark varied with the speed of the pinions.

Fig. 3 is a diagrammatic elevation of the arrangement shown in Fig. 2, with the photoelastic apparatus included. Fig. 4 is a view of the set-up employed in the tests.

The Tests.—Two celluloid sections of ½-in. face and of the type of pinion shown in Fig. 5 have been examined thus far. The radial pressure applied corresponded to a maximum $(\widehat{rr} - \widehat{\theta\theta})$ at the bore of the pinion of 845 lb. per sq. in. where $\widehat{rr}$ and $\widehat{\theta\theta}$ are respectively the radial and tangential principal stresses.

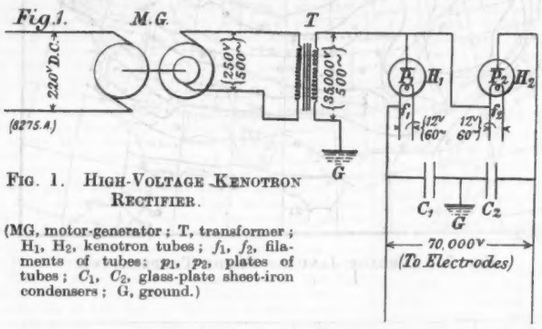


FIG. 1. HIGH-VOLTAGE KENOTRON RECTIFIER.

(MG, motor-generator; T, transformer; H_1, H_2, kenotron tubes; f_1, f_2, filaments of tubes: p_1, p_2, plates of tubes; C_1, C_2, glass-plate sheet-iron condensers; G, ground.)

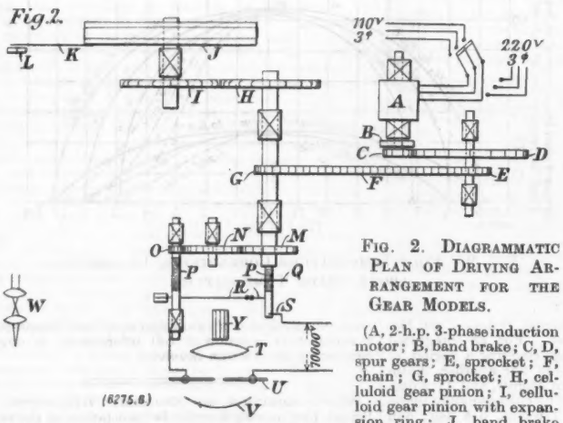


FIG. 2. DIAGRAMMATIC PLAN OF DRIVING ARRANGEMENT FOR THE GEAR MODELS.

(A, 2-h.p. 3-phase induction motor; B, band brake; C, D, spur gears; E, sprocket; F, chain; G, sprocket; H, celluloid gear pinion; I, celluloid gear pinion with expansion ring; J, band brake with dynamometer; K, sighting arm; L, fixed index; M, N, O, spur gears; P, fibre shaft; Q, fibre shield; R, arms; S, brush; T, collecting lens; U, electrodes; V, reflector; W, telescope; Y, polariser and analyser.)

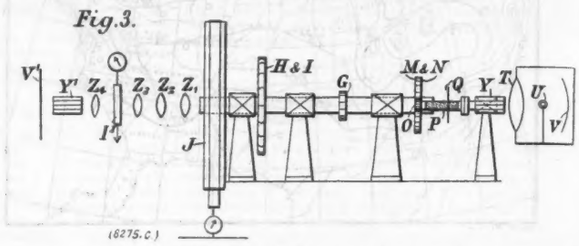


FIG. 3. DIAGRAMMATIC ELEVATION OF ARRANGEMENT SHOWN IN FIG. 2, WITH PHOTOELASTIC APPARATUS INCLUDED.

(I', comparison member for stress determination; V', screen or photographic plate; Z_1, Z_2, Z_3, Z_4, lenses. Other letters as in Fig. 2.)

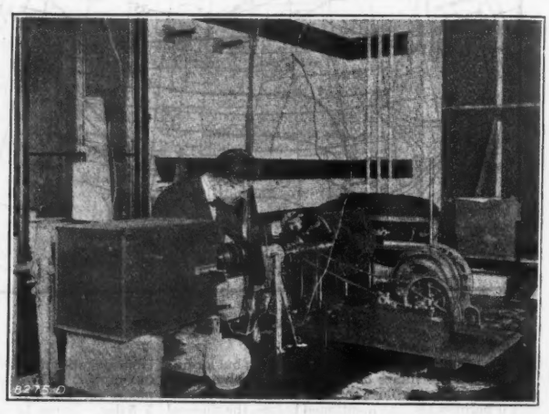


FIG. 4. VIEW OF SET-UP EMPLOYED IN THE TESTS.

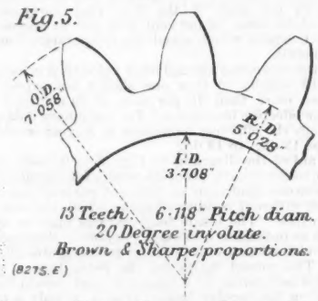


FIG. 5. TOOTH FORM OF PINION SUBJECTED TO PHOTOELASTIC ANALYSIS.

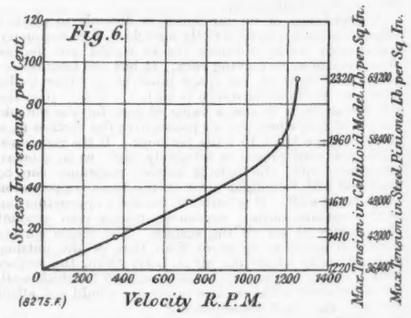


FIG. 6. INCREASE OF MAXIMUM TENSION IN CELLULOID MODEL AND STEEL PINION WITH INCREASING SPEED.

A resisting torque of 125 in.-lb. was applied, giving a total tractive force per inch of face of the pinion, tangential in direction to the pitch circle, of 164 lb.

As long as Hooke's law of linear proportionality between stress and strain holds, any linear simultaneous proportional increase of the radial pressure and the tractive force will produce the same linear proportional increase of the stresses set up in the pinion. Therefore the loads applied to the model will correspond to different loads in the steel pinions bearing the same ratio as in the model. In other words, the celluloid model will give a true reproduction of the stress distribution for a steel pinion under similar loading conditions. To transform from the model to the steel pinion, multiply the stresses in the celluloid pinion by the ratio of the loads on the steel pinion to the loads on the celluloid model.

The maximum tensile stresses occurring at the root of the tooth in mesh have been measured for different

* Paper submitted to the American Society of Mechanical Engineers at the New York meeting in December, 1923.

† Trans. A.S.M.E., vol. xliv, page 513.

speeds. The results for the model and for the steel pinion are given in Table I and the maximum stresses are plotted against increasing speed in Fig. 6.

What is particularly noticeable in the results presented in Table I is the marked increase in maximum stress due to rotation, amounting to nearly a 100 per cent. increase for a speed of 1,250 r.p.m. These results are extremely interesting, though of a preliminary nature. The study is being continued.

TABLE I.—*Results of Tests of Celluloid Model and Steel Pinion.*

R.p.m.	Maximum Tension.* (lb. per sq. in.)		Per Cent. Increase compared with Static Torque.
	Celluloid Model.	Actual Pinion†	
0	1,220	36,400	0
360	1,410	42,000	16
720	1,610	48,000	33
1,170	1,960	58,400	62
1,248	2,320	69,200	92

* At the root of the tooth at the tension side.
† For a ratio of torque and inside radial pressure in model and steel pinion of 1 : 297.

GERMAN IRON AND STEEL PRICES.—Dealing with recent German quotations, the *Iron Trade Review*, Cleveland, Ohio, says gold marks do not exist, paper marks have practically no value and renten marks do not possess a definite foreign exchange value. So when it comes to actual transactions most of the German export business is done in sterling and also a fair share of the internal business. The dollar equivalents of the existing sterling prices show that German quotations are not above the world market level. In fact, a good many export orders have recently been taken by German producers for shipment to Japan, South America, India and other parts at 10 to 15 per cent. under world market levels. By juggling the exchange, the Germans at present are attempting to make the outside world believe that their prices and costs are higher than is really the case. Well-informed experts on international iron and steel trade are not deceived by these tactics.

STANDARDISATION OF SHIPS' FITTINGS.—Specifications recently issued by the British Engineering Standard Association cover stud-link anchor cables, end (or bending) shackles for attaching cables to anchors, and cable fittings known as "devil's claws." The cable specification, we may mention, has been drawn up with the co-operation of the Board of Trade, Lloyd's and other Register Societies, as well as of makers of cables and windlasses, and its adoption by shipowners would greatly minimise the difficulty hitherto met with from the links of the cable not bedding properly into the lifters of the windlass. The cables dealt with range from $\frac{7}{8}$ in. to 3 in. sizes in steps of $\frac{1}{8}$ in., and the same range is also covered by the specification for end shackles. Another specification just issued by the Association relates to hand-screw (aft) steering gear, specifying the main dimensions and leaving the general design to be decided upon by the manufacturer. The chief points covered are the number and diameter of the steering wheels, the distance from the centre of the rudder stock to the centres of the cross-head pins and the diameter of the screw threads, the dimensions being given for rudder stocks ranging from 3$\frac{1}{2}$ in. to 12 in. in diameter. Copies of any of these publications can be obtained from the Association's offices at 28, Victoria-street, London, S.W.1, price 1*s.* or 1*s.* 2*d.* post free.

THE NEW WAUKEGAN POWER STATION.—Particulars are given in our American contemporary *Power* of the recently started power station at Waukegan, which is to have an ultimate capacity of 250,000 kw. The first unit to be installed is a 25,000 kw. Allis Chalmers turbo-generator running at 1,800 r.p.m. and generating current at 12,000 volts. Three boilers, each with 14,086 sq. ft. of heating surface, supply steam to the unit, although full load can be carried by two boilers only. The working pressure is 400 lbs. per sq. in. and the steam is superheated to 700 deg. F., the pressure and temperature at the turbine throttle being 350 lb. and 650 deg. F. respectively. The boilers are of the Babcock & Wilcox marine type with superheater of 2,286 sq. ft. surface located between the upper and lower bank of tubes. The economiser surface is 8,837 sq. ft. Arrangements have been made for the future provision of an air pre-heater beyond the economiser. The normal evaporation of each boiler is said to be 120,000 lb. per hour. To get the large furnace volume desired, the bridge wall was moved back to serve as the rear wall of the setting, and the average height of the lower tubes from the grates was made 16 ft. 6 in. A primary combustion volume of 4,300 cu. ft., including the space under the arch was thus obtained. The boilers are fixed by fire-zone forced draught, chain grated stokers, each grate being 18 ft. 3 in. long by 21 ft. wide, giving a fire area of 383 sq. ft. The condenser for the main turbo-generator is of the two pass type, about 12 ft. diameter, with a cooling surface of 32,000 sq. ft., made up of one 1-in. tubes 20 ft. 3 in. long. When condensing 220,000 lb. of steam per hour with 70 deg. cooling water, it is designed to give a pressure of 1·6 in. absolute. Cooling water is supplied by one 36 in. circulating pump driven by a 300 h.p. two-speed a.c. motor running at either 435 or 390 r.p.m. At the former speed the pump will deliver 35,000 (American) gallons per minute against a 25 ft. head.

CATALOGUES.

Haulage Gears.—A small 4-page pamphlet showing six types of the Carron haulage gear, ranging from 30 h.p. to 300 h.p., is to hand from Messrs. Cowlishaw-Walker and Co., Limited, Stoke-on-Trent, who are the selling agents for England and Wales.

Cast-Iron Pipes.—The monthly stock list of spun cast-iron pipes issued by the Stanton Ironworks Company, Limited, near Nottingham, states that the demand is so brisk that deliveries from stock are not practicable at present. This applies to all sizes.

Tin-can Soldering Machines.—A catalogue of the Luxton-Green tin-can soldering machine, together with a reprint of the full description of the machine which appeared in our issue of November 23 last, is to hand from Messrs. William A. Green, Limited, 200, Westminster Bridge-road, London, S.E.1.

Gear Grinding.—A full and practical discussion of the advantages of grinding gear teeth appears in a little pamphlet issued by the Gear Grinding Company, Limited, Handsworth, Birmingham. The design of gear boxes, the whole series of operations for machining gear wheels, and the grinding of splined shafts are dealt with.

Building Blocks.—Messrs. J. H. Sankey and Son, Limited, Essex Wharf, Canning Town, London, E. 16, have issued a catalogue of partition blocks, floor blocks, bricks, &c., made in a variety of shapes (generally hollow) from "moler"—a natural material found in Denmark, which has exceptionally sound and heat-insulating properties and is also very light.

Ball and Roller Bearings.—A new edition of their catalogue of ball and roller bearings received from the Hoffman Manufacturing Company, Limited, Chelmsford, contains lists of dimensions and prices of ball journal bearings, roller journal bearings, rigid pedestals, narrow roller journal bearings, together with some useful notes on lubrication and fit allowances.

Testing Machines.—Two catalogues are to hand from Messrs. Alfred J. Amsler and Co., Shaffhouse, Switzerland: one showing a large range of machines for carrying out tensile hardness, insulation, abrasion, impact, bending, compression, and other tests; and another dealing with torsion dynamometers, in which the stroboscopic principle is employed for taking readings.

Tool Steels.—A small 8-page catalogue of plain carbon tool steels, issued by Messrs. Edgar Allen and Co., Limited, contains much useful information relating to the numerous tools for which these steels are suitable and the heat treatment and other working methods. The firm have also sent a copy of their periodical, *The Edgar Allen News*, the contents of which are all of practical value, especially the articles on chisel steels and on circular saws.

Jacks.—A catalogue of lifting jacks, with modified forms for pulling, expanding, traversing, pipe forcing, &c., is to hand from the Consolidated Pneumatic Tool Company, Limited, 170, Piccadilly, London, W. 1, who are agents in Europe for the makers, the Duff Company, of Pittsburg, U.S.A. The pipe jack is intended for forcing pipes through the ground from one pit to another, to avoid the necessity for digging a trench for the full length of the run of the pipe.

Ships' Lights.—The Carron Company, Falkirk, have issued a 60-page catalogue of framed openings for port-holes, saloon lights, deckhouse lights, &c., and also cargo openings for ships' sides. A very wide range of forms and qualities and a useful variety of opening and locking methods are dealt with. The frames are made from gunmetal, brass, cast-steel or cast-iron, and the cargo ports, which, of course, are not glazed, are closed by means of bridge pieces similar to those used with manholes.

Steel Belt Conveyors.—A catalogue of belt conveyors in which steel is used for the carrying belt has been received from Steel Belt Conveyors, Limited, Norwich Union Chambers, Congreve-street, Birmingham. The belts are a Swedish product, the standard widths ranging from 8 in. to 24 in. in steps of 2 in., and the thicknesses varying from 0·043 in. to 0·016 in.; they can be made in single lengths up to 350 ft. A sample of hardened, tempered and polished sheet spring steel enclosed with the catalogue is 0·0024 in. thick and has an extremely fine finish.

Utilisation of Waste Heat from Coke.—An article by Dr. Schläpfer of Zurich, explaining the Sulzer process of "dry quenching" coke, forms the substance of a catalogue issued by the Semet-Solvay and Piette Coke Oven Company, Limited, 155, Norfolk-street, Sheffield, who have acquired the patent rights for this country in so far as the manufacture of metallurgical coke in coke ovens is concerned. The process substitutes for water quenching the extraction of the heat by a current of inert gas, which is passed on to the boiler flues. An installation is mentioned for raising steam at a pressure of 220 lb. per square inch with superheat.

Motor-car Spare Parts.—Messrs. Ruston and Hornsby, Limited, Lincoln, have recently issued a new edition of their catalogue of spare parts for the Ruston-Hornsby cars—a publication which is to be commended for the excellent method of compilation. The car is divided into "unit assemblies," of which there are 25, and these are given in a table with reference letter and figure, with a brief general description, and reference to catalogue pages for each. A list of the parts in each unit follows, with part number and all particulars for ordering. The list occupies 76 octavo pages, with text and line drawings, and serves for both the 16-h.p. and the 20-h.p. cars. The stock and arrangements enable the firm to dispatch parts within a few minutes of the receipt of the order.

Clutches.—A new edition of their catalogue of automatic clutches, pulleys, couplings and brakes, containing new tables, illustrations and technical matter is to hand from Messrs. Thomas Broadbent and Sons, Limited, Huddersfield. Several types of clutches for various applications are described, including one that may be set to take up the drive only when the motor has attained four-fifths of its full speed—a useful feature for electric drives employing motors having a low starting torque. The clutches are made in standard sizes for transmitting definite maximum horse-powers at given speeds. For example, the smallest will transmit $\frac{1}{4}$ h.p. at 800 r.p.m. and 9 h.p. at 2,100 r.p.m., while the corresponding figures for the largest size listed are 108 h.p. at 300 r.p.m. and 2,000 h.p. at 800 r.p.m. The technical matter in the catalogue is useful and clearly written.

Reinforced Concrete Structures.—An excellently produced catalogue has reached us from Messrs. Saxild and Partners, 2, Central-buildings, S.W., illustrating examples of work carried out by that firm in reinforced concrete. This catalogue consists of some 62 pages devoted almost wholly to line and half tone engravings. The variety of work is very considerable ranging from jetties and quay walls and breakwaters, to bridges, power stations, silos, sea-plane hangars, workshops, granaries, &c., and concluding with a number of miscellaneous works of too varied a character to classify. One of the important examples is the construction of a reinforced concrete workshop at Elsinore, over an existing shop and without stopping the work in the latter. This it will be remembered we dealt with at length in ENGINEERING as recently as November 2 last, page 547. It is, however, only one of many interesting structures successfully carried out lately by this firm.

Locomotives.—An interesting catalogue of locomotives has recently been issued by Messrs. Beyer, Peacock and Co., Limited, Gorton, Manchester. It consists of a list of 70 types, each of which is illustrated and accompanied by a brief specification printed in English, French and Spanish. There are five sections to the catalogue dealing with broad-gauge, standard gauge and narrow-gauge engines, Garrat locomotives and crane and rack rail locomotives. These include types in common use on the English, Irish, South American, Chinese, Australian, Indian and other railways for fast passenger, heavy goods and shunting service. Practically all requirements are covered in the list, which is remarkably comprehensive. Two crane locomotives illustrated were built for New South Wales and Argentine railways respectively, and each is capable of lifting five tons, the first at 11-ft. radius and the second at 18-ft. radius. An illustration of a tender locomotive built in 1862 for a Portuguese railway and still in service makes an excellent, frontispiece to the catalogue.

Cable-Making Machinery.—A comprehensive range of machinery for the manufacture of electric cables is illustrated, chiefly by means of line drawings, in a special catalogue issued by Messrs. David Bridge and Co., Ltd., Castleton, Manchester. The wire-drawing machines illustrated include one of the nine-die continuous vertical roll type for drawing copper wire from 3 S.W.G. to 16 S.W.G. or intermediate sizes, a single wire-drawing block, and a 10-die continuous cone type machine for drawing wire from 15 S.W.G. to 26 S.W.G. These are followed by machines for winding, measuring and stranding the wire, rubber lapping or taping machines, longitudinal covering machines, winding gear for vulcanising drums, vulcanising pans, compound serving tank, bitumen covering machine, paper lapping machine, &c. Presses and dies for the manufacture of lead pipes and for sheathing cables with lead are also illustrated, together with hose armouring machines and a machine for cutting rings, threads and washers. The remainder of the catalogue is occupied by a series of illustrations of a very comprehensive range of rubber-making plant and machinery.

"STEEL'S TABLES."—Merchants, contractors and manufacturers have frequently to translate values from one denomination into another, such, for example as thicknesses from decimals of inches or fractions of millimeters, into gauge figures, British lengths, weights, pressures, &c., into metrical and vice-versa. Weights of bars, sheets, galvanised corrugated sheets, &c., per given dimensions, are often required rapidly for estimating purposes. Such particulars and many others of the same nature are to be found in a small booklet having the above title, measuring 6$\frac{1}{2}$ by 4$\frac{1}{2}$ in., and containing 126 pages, compiled by Joseph Steel, and issued at the price of 3*s.* 6*d.* net by Messrs. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, W.C.2.

A FRENCH LAW CASE.—The maxim that silence gives consent often holds good in law, says the Bulletin of the British Chamber of Commerce, Paris. In July, 1913, a small Paris manufacturer hired a pump from a maker. As his business increased, he hired other pumps and an electric motor. He paid the hire regularly until August, 1916, when, having discovered that the total amount of the hire, about 14,000 fr., was more than the value of the plant, he wrote to the maker requesting, in accordance with trade usages, that the hire payments should be considered as purchase money. The maker did not reply, and took no steps until 1921, when he sued for five years' hire. The Tribunal of Commerce held that the absence of a reply to the hirer's letter amounted to consent, and gave judgment for the defendant.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

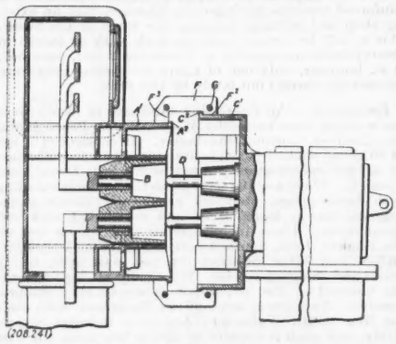
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

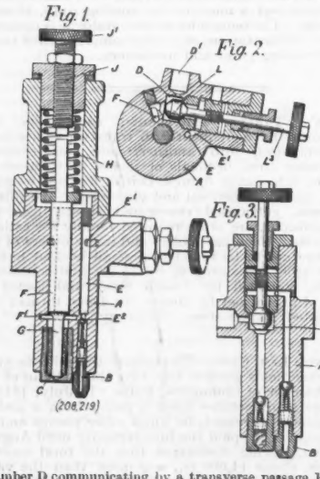
208,241. A. Reyrolle and Company, Limited, Hebburn-on-Tyne, J. Mirrey, East Boldon, and F. N. Linstow, Hebburn-on-Tyne. Electrical Switches. (2 *Figs.*) September 16, 1922.—The invention has reference to switches of the iron-clad draw-out type used on high voltage circuits. According to the invention, a cover or shield F is provided which, whilst allowing for the relative movement between the members of the auxiliary or isolating switch or switches B, D, completely surrounds them and prevents the exit of any spark or flame which, under abnormal conditions, might possibly occur and also prevents the inlet of any dust, debris or moisture. In carrying out the invention, the cover or shield F is made of cylindrical shape



divided longitudinally at F1 into two parts which can be placed round the appropriate portions of the iron casings A1, C1 of the switch members so as to form a sliding joint with either or both of them. The cover or shield F encloses both the main isolating contacts B, D, connected in the primary circuit, and the secondary isolating contacts, connected in such low-tension circuits as the trip coil and meter circuits. The parts of the cover F are secured by bolts G and are formed with internal flanges F3, F2 at each end where they bear on the casings C1, A1 of the switch members. Such casings are preferably provided with small external flanges C2, A2, which act as stops or abutments to prevent accidental disengagement of the outer cover or shield F. (*Accepted December* 28, 1923.)

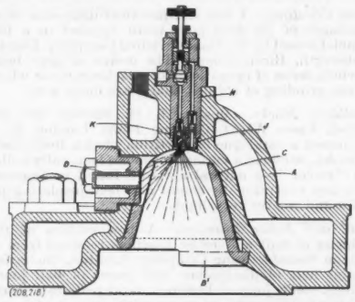
GAS ENGINES, PRODUCERS, HOLDERS, &c.

208,219. J. Samuel White & Co., Limited, East Cowes, and A. Forster, Cowes. Semi-Diesel Engines. (4 *Figs.*) September 13, 1922.—The invention relates to fuel injection devices for semi-Diesel engines of the kind employing separate starting and working fuel sprayers, only one of which delivers fuel to the combustion chamber on each engine cycle. The fuel spraying device comprises a removable plug A containing a sprayer B for starting purposes and a second sprayer C for normal working. Fuel is supplied to the starting sprayer from



a chamber D communicating by a transverse passage E1 with a vertical passage E, the lower end of which is controlled by means of a ball valve E2 normally held closed by means of a spring. Communicating with the fuel chamber D by a vertical passage F is an annular fuel delivery chamber F1 formed just above the fuel nozzle C. The fuel discharge aperture is controlled by means of a vertical plunger G normally held closed by a spring H, the upward movement of the plunger being limited by means of an adjustable stop J having an operating head J1. Fuel from a common source of supply enters the fuel chamber D by an inlet port D1. The supply of fuel from the chamber D to the starting nozzle B or to the main working nozzle C is controlled by means of a common valve L. This valve is provided with two conical faces respectively controlling the flow of fuel into the passages E and F. The arrangement is such that when the valve L is actuated by means of its screw-threaded shaft L3, the supply of fuel from the chamber D is cut off from the passage F simultaneously with the opening of the passage E and *vice-versa*. (*Accepted December* 28, 1923.)

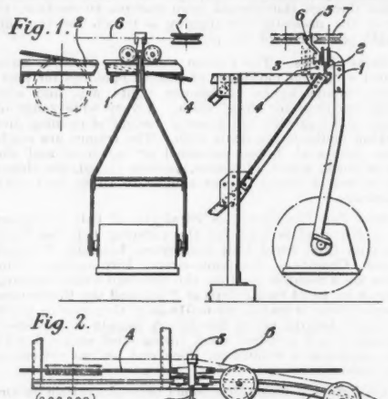
208,218. J. Samuel White & Co., Limited, East Cowes, and A. Forster, Cowes. Semi-Diesel Engines. (1 *Fig.*) September 13, 1922.—The invention relates to semi-Diesel engines of the type in which a combustion chamber is provided on the cylinder head entirely surrounded by a water-jacket. In such cases the combustion chamber is apt to become too cool and to prevent this, it is usual to employ a liner, with or without a hot spot against which the fuel jet is sprayed and thus vaporised. According to the invention, not only is the water-cooled cylinder head A formed as a single unit, but the removable liner C is maintained in place within the cylinder head, after being inserted therein from below, by means of a bayonet joint B1 held



against unintentional disengagement by a removable locking member D engaging a slot in the wall of the liner. Preferably projecting lugs or flanges on the base of the liner C engage slots in the wall of the cylinder head B and so constitute a bayonet joint, and the locking member D conveniently also constitutes the hot spot and can be removed from outside without dismantling the cylinder head or the liner. If desired, the liner may be split to allow for its expansion and, if separate starting and working fuel sprayers J, K are employed, these are conveniently mounted in a common plug H adapted to engage a single opening in the wall of the vaporising chamber B so that only a single joint is necessary for both sprayers. (*Accepted December* 28, 1923.)

LIFTING AND HAULING APPLIANCES.

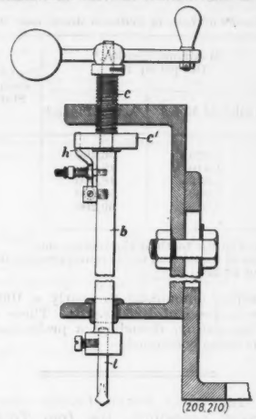
208,302. G. A. Main, Westminster, London, and S. G. Mann, Westminster, London. Rope Conveyors. (3 *Figs.*) October 25, 1922.—The invention relates to aerial rope-ways employed for transporting goods by means of moving cables supported at intervals by trestles or towers, and has for its object to provide in connection with a single rope system, improved supplementary driving means at return ends and bends capable of positively transferring the carriers from a position adjacent to or after which they break driving connection with a running rope to a position at which they are again brought into driving connection therewith. The carrier 1 is shown supported by a guide rail 2, the rope clip 3 having been freed from the rope 4, which is run down below the level of the rail, and the chain clip 5 having been engaged by a chain 6, both clips being suitably con-



nected to the carrier. As the supporting rollers of each carrier come into engagement with the station rail the carrier is lifted out of engagement with the rope, and is thereupon engaged (the clip entering between links) by an endless chain, which moves in a path conforming with the course of the rail. The chain moves out of engagement with the chain clip near to the place of re-engagement of the carrier in a similar manner to the driving rope. Means are provided for guiding the chain in its desired path and comprise a series of guide pulleys 7. The chain clip 5 is so positioned in relation to the rail that the chain is carried out of contact with each guide pulley or set of guide pulleys as the carrier passes that particular pulley or set, the carrier engaging with guides which first divert the clip out of its normal path and then allow it to return thereto, after the pulley has been passed. (*Accepted December* 28, 1923.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

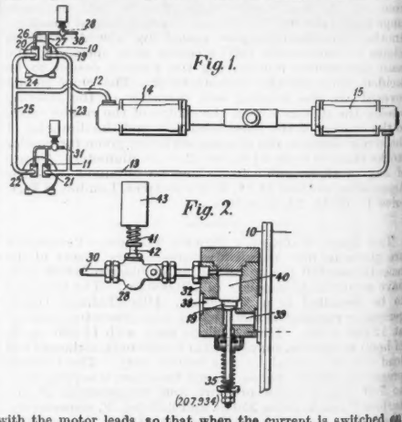
208,210. F. Chopping, Hornsey, London. Hand and Power Drilling Machines. (3 *Figs.*) September 11, 1922.—The invention provides simple and convenient means to feed forward the drill or cutting tool under such conditions that excessive feed and the fracture of the drill or cutting tool are prevented. According to the invention, a spring pawl device *h* is carried directly upon the drill spindle *b*, the free end of which pawl device is adapted to engage within a notch or notches in a collar or flange *c*1 integrally formed with or mounted upon a screw threaded bush or sleeve *c*, the arrangement being such that on undue resistance being encountered by the drill or cutting tool *i* the spring pawl *h* slips out of its notch whereupon the drill spindle *b* rotates while movement is not communicated to the



screw threaded bush or sleeve *c* and the pawl *h* will, on the continued rotation of the spindle, continue to slip the notch until the resistance encountered by the drill or cutting tool becomes less than that offered to the pawl in moving out of its notch. (*Accepted December* 28, 1923.)

PUMPS.

207,934. John Hastie and Company, Limited, Greenock, and W. G. Riddell, Greenock. Hydraulic Steering Gear Pumps. (2 *Figs.*) October 4, 1922.—The invention relates to the control of electrically-driven pumps of hydraulic steering gear. 10 and 11 are two electric motor-driven pumps which are connected to the common mains 12 and 13 communicating with the opposite ends of the steering cylinders 14 and 15. Each of the pumps 10 and 11 is provided with two valves 19, 20 and 21, 22 and with connections to both mains, the pump 10 being connected through the valve 19 and pipe 23 with the main 13 and through the valve 20 and pipe 24 with the main 12, while pump 11 is connected through the valve 21 directly with the main 13 and through the valve 22 and pipe 25 with the main 12. The upper part of each valve chamber is connected by pipes 26 and 27 respectively to relay valves 28 forming part of relay systems 30 and 31, which communicate with a common tank or reservoir. Each of the four valves 19, 20, 21 and 22 is in the form of an isolating valve, shown at 19 in Fig. 2, in a casing 32. This valve is provided with a spring 35 arranged to hold the valve on its seating. The passage 38 in valve casing 32 communicates with the main leading to the steering cylinders 14 and 15, while the passage 39 communicates directly with the pump 10. The upper cylindrical and enlarged part 40 of the valve slides loosely in a bore in the valve casing 32 and the space above the part 40 communicates with the relay valve 28. Each relay valve 28 is provided with a spring 41 arranged to close the valve on its seat 19 and an extension of the valve spindle 42 is provided with a solenoid 43 in circuit



with the motor leads, so that when the current is switched on to one of the pump motors the solenoid of the associated relay valve is energised and the relay valve held open thereby so that the pump can operate the steering gear. When the current to the motor fails or is cut off intentionally, the solenoid at once ceases to operate and the relay valve is closed by its spring. The isolating valve will now be held firmly on its seat under all conditions and the pump completely isolated. When the pump 10 is in operation, the current to its motor energises the solenoid 43 which lifts the relay valve 28 and holds it open against the resistance of the spring 41, and when this relay valve is open the oil or liquid leakage along the peripheral surface of the cylindrical and enlarged part 40 of the isolation pump valve 19 is free to escape and no pressure is built up above this valve while any oil delivered from the pump 10 through the passage 39 will raise the valve 19 off its seat and allow oil to pass to the cylinders 14 and 15. When the passage 39 acts as a return passage, the oil returning through passage 38 operates on the annular area formed between the valve 19 and the cylindrical and enlarged part 40 and lifts the valve off its seat, allowing oil to return freely to the pump 10. When the current driving the motor 10 is cut off or fails, the solenoid 43 will at once become inoperative and the spring 41 will close the relay valve 28, the leakage now passing the cylindrical and enlarged part 40 of the valve 19 accumulates in the space above the valve and prevents it rising from its seat, thus isolating the passage 38 from the passage 39. When the passage 38 is operating as a return passage, the spring 35 keeps the valve 19 on its seat and closes the passage 39. (*Accepted December* 19, 1923.)